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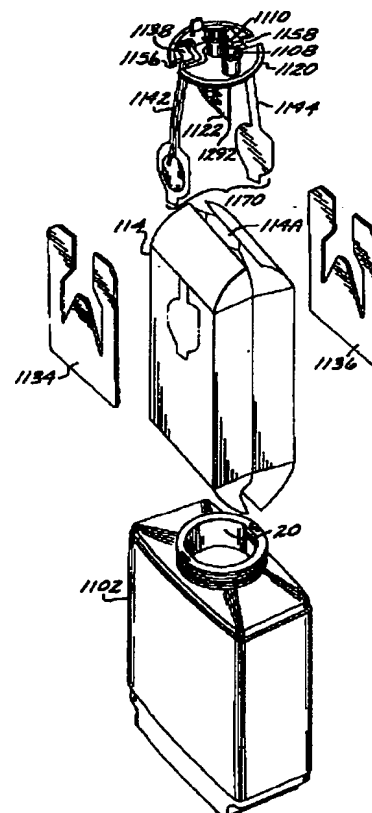
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(54) Title: INK CONTAINER PROVIDING PRESSURIZED INK WITH INK LEVEL SENSOR

(57) Abstract

An ink container for an off-carriage printing system including an ink supply station. The ink container contains a collapsible reservoir (114) filled with ink that is fluidically connectable to a conduit that leads to a pressure regulator. The outlet of the regulator delivers ink to a printhead. A pressure vessel (1102) surrounds the reservoir. The system pressurizes the pressure vessel, which results in pressurized ink being delivered to the regulator. The ink container has a sensor that infers the actual volume of ink in the reservoir by sensing the relative position of the reservoir walls. This sensor is mounted between the pressure vessel and the collapsible reservoir. The sensor is electrically connected to pads that are accessible from the outside of the ink container. Leads route from the pads, through a seal zone, and to the sensor. The seal is provided by a compressed o-ring.



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INK CONTAINER PROVIDING PRESSURIZED
INK WITH INK LEVEL SENSOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to the following co-pending patent applications, each of which is incorporated herein by this reference: Docket number 10970423, entitled ELECTRICAL INTERCONNECT FOR AN INK CONTAINER, filed herewith; Docket number 10970424, entitled METHOD AND APPARATUS FOR SECURING AN INK CONTAINER, filed herewith; Docket number 10970426, entitled REPLACEABLE INK CONTAINER ADAPTED TO FORM RELIABLE FLUID, AIR AND ELECTRICAL CONNECTION TO A PRINTING SYSTEM, filed herewith; Docket number 10970427, entitled INK CONTAINER WITH AN INDUCTIVE INK LEVEL SENSE, filed herewith; Docket number 10970428, entitled INK LEVEL ESTIMATION USING DROP COUNT AND INK LEVEL SENSE, filed herewith; Docket number 10970430, entitled AN INK CONTAINER HAVING A MULTIPLE FUNCTION CHASSIS, filed herewith; Docket number 10970431 entitled HIGH PERFORMANCE INK CONTAINER WITH EFFICIENT CONSTRUCTION.

TECHNICAL FIELD OF THE INVENTION

The present invention concerns replaceable ink supply containers for providing ink to a high flow rate ink delivery system.

BACKGROUND OF THE INVENTION

High throughput printing systems, such as those used in high speed printers and color copiers, or large format devices put heavy demand on an ink delivery system. The printhead must operate at a very high frequency. At the same time, print quality expectations keep rising. In order to maintain high print quality, the printhead must be able to rapidly eject ink without causing large fluctuations in the printhead pressure level.

One approach to this is to provide a pressure regulator integral to the printhead. The regulator receives ink at a first pressure and delivers ink to the printhead at a controlled second pressure. In order for this control to work, the first pressure must always be greater than the second pressure. Because of dynamic pressure drops, very high pixel rate printing requires that the first pressure be at a positive gauge pressure.

One example of an ink cartridge that can be pressurized is described in U.S. Patent 4,568,954. Other references include U.S. Patent Nos. 4,558,326; 4,604,633; 4,714,937; 4,977,413; Saito 4,422,084; and 4,342,041.

One problem with previous high throughput devices is predicting when the consumable will be exhausted. It is important that the system stop printing when the ink cartridge is nearly empty, with a small amount of stranded ink. Otherwise, dry firing and consequent printhead damage may occur. Printheads for such high throughput devices tend to be expensive. What is needed is an ink cartridge that offers pressurized ink and provides an accurate means of indicating low ink.

Various ways have been developed for detecting the amount of ink in an ink container. However, this problem becomes very difficult when the ink is to be pressurized. In such a case, the ink must be held in a pressure vessel.

U.S. Patent 4,568,954 employs electrodes that measure a resistance path through the ink. A problem with this approach is that it is dependent upon electrical properties of the ink. What is needed is a way of sensing the volume of the ink in a collapsible bag reservoir that is surrounded by a pressure vessel. Further, what is needed is a way of accessing the sensing signal without negatively impacting the integrity of the construction.

SUMMARY OF THE INVENTION

This invention is an ink container for use in an off-carriage printing system. The ink container contains a collapsible reservoir filled with ink that is in fluidically connectable to a conduit that leads to a pressure regulator. The outlet of the regulator delivers ink to a printhead. A pressure vessel surrounds the bag. The system pressurizes the pressure vessel, which results in pressurized ink being delivered to the regulator.

The ink container has a sensor that infers the actual volume of ink in the reservoir by sensing the relative position of the reservoir walls. This sensor is mounted between the pressure vessel and the collapsible reservoir.

The sensor is electrically connected to pads that are accessible from the outside of the ink container. Leads route from the pads, through a seal zone, and to the sensor. The seal is provided by a compressed o-ring.

In accordance with another aspect of the invention, a method of assembling an ink container to be installed in an inkjet printing system is described, the inkjet printing system having a printhead for ejecting ink on media. The method comprises the steps of:

- (a) providing a first housing member including a fluid pathway with a fluid outlet for providing ink to said printhead;

(b) fluidically coupling a collapsible reservoir to said fluid outlet;

(c) attaching an ink level sensing circuit to said collapsible reservoir;

5 (d) attaching a plurality of container contacts on an outside surface of said first housing member;

(e) routing a plurality of electrical paths that couple said sensing circuit to said container contacts;

10 (f) attaching a second housing member to said first housing member, said second housing member abutting said first housing member along a seal zone, said first and second housing members forming a pressure vessel that surrounds said collapsible reservoir, said pressure vessel and said collapsible reservoir defining a pressurized region therebetween, said plurality of electrical paths passing through
15 said seal from said pressurized region to said outside atmosphere.

20

BRIEF DESCRIPTION OF THE DRAWING

These and other features and advantages of the present invention will become more apparent from the following
25 detailed description of an exemplary embodiment thereof, as illustrated in the accompanying drawings, in which:

FIG. 1 is a schematic block diagram of a printer/plotter system in accordance with the invention.

30 FIG. 2 is schematic block diagram illustrating in a simplified fashion an exemplary off-carriage ink container, with connection to an on-carriage print cartridge, and an air compressor for pressuring the off-carriage pressure vessel comprising the off-carriage ink container.

35 FIG. 3 is a simplified isometric view of a printer/plotter employing the present invention.

FIG. 4 is an exploded isometric view of a simplified implementation of an ink container pressure vessel, collapsible reservoir, ink level sensing circuitry and a chassis member showing features of the invention.

5 FIG. 5A is a bottom isometric view of a simplified implementation of an ink container in accordance with the invention, with the elements of FIG. 4 assembled into the pressure vessel, and with the leading and trailing end caps shown in a detached state.

10 FIG. 5B is a top isometric view of the simplified implementation of FIG. 5A.

FIG. 6 is an isometric view of the pressure vessel of the off-carriage ink container.

15 FIG. 7 is a side view of the off-carriage ink container.

FIG. 8 is a partial front view of the chassis structure comprising the off-axis ink container.

FIG. 9 is an end view of the off-carriage ink container, showing the leading cap.

20 FIG. 10 is a cross-sectional view of the off-carriage ink container, taken along line 10-10 of FIG. 9.

FIG. 11 is a cross-sectional view of the off-carriage ink container, taken along line 11-11 of FIG. 9.

25 FIG. 12 is a cross-sectional view of the chassis structure, taken along line 12-12 of FIG. 11.

FIG. 13 is a top view of a ink level sensing coil attached to the ink reservoir bag comprising the off-carriage container, in the area shown by line 13-13 of FIG. 10.

30 FIG. 14 is an isometric view of the chassis member with the sensor leads in place.

FIG. 15 is an inverted isometric view of the chassis member of FIG. 14.

35 FIG. 16A is a top view of the flexible circuit carrying the ink level sensing circuitry assembled with the ink

container. FIG. 16B is an isometric view of the collapsible reservoir, attached to the chassis, with the ILS flexible circuit attached to the reservoir and to the chassis.

5 FIG. 17 is a side view of the neck region of the pressure vessel, showing the attached leading end cap in cross-section.

10 FIG. 18 is a cross-sectional view taken along line 18-18, showing a locking feature for locking the leading cap in position on the pressure vessel.

FIG. 19 is a bottom view of the leading cap of the ink reservoir taken from line 19-19 of FIG. 17.

FIG. 20 is a cross-section view showing the trailing end of the pressure vessel with the trailing cap.

15 FIG. 21 is an enlarged view of the area indicated as area 21 in FIG. 20, showing the adhesive attachment of the trailing cap to the pressure vessel.

20 FIG. 22 is an isometric view of the off-carriage docking station for the off-carriage ink reservoirs comprising the printer/plotter system of FIG. 3.

FIG. 23 is an isometric view of a portion of the leading edge cap, showing the locking features.

FIG. 24 shows keying features for the leading end cap for different ink colors.

25 FIG. 25 shows keying features for the leading end cap for different product types.

FIG. 26 is an assembly flow diagram illustrating an assembly process for assembling the ink container.

30 FIG. 27 is a partial side cross-sectional exploded view of the ink container illustrating assembly.

FIG. 28 is an isometric exploded view showing the assembled pressure vessel/reservoir with the leading end and trailing end caps.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTOverview of the System.

FIG. 1 shows an overall block diagram of a printer/-
5 plotter system 50 embodying the invention. A scanning
carriage 52 holds a plurality of high performance print
cartridges 60-66 that are fluidically coupled to an ink
supply station 100. The supply station provides pressur-
ized ink to the print cartridges. Each cartridge has a
10 regulator valve that opens and closes to maintain a slight
negative gauge pressure in the cartridge that is optimal
for printhead performance. The ink being received is
pressurized to eliminate effects of dynamic pressure drops.

The ink supply station 100 contains receptacles or
15 bays for slidable mounting ink containers 110-116. Each
ink container has a collapsible ink reservoir, such as
reservoir 110A that is surrounded by an air pressure
chamber 110B. An air pressure source or pump 70 is in
communication with the air pressure chamber for pressuriz-
20 ing the collapsible reservoir. Pressurized ink is then
delivered to the print cartridge, e.g. cartridge 66, by an
ink flow path. One air pump supplies pressurized air for
all ink containers in the system. In an exemplary embodi-
ment, the pump supplies a positive pressure of 2 psi, in
25 order to meet ink flow rates on the order of 25 cc/min. Of
course, for systems having lower ink flow rate requirement,
a lower pressure will suffice, and some cases with low
throughput rates will require no positive air pressure at
all.

30 FIG. 2 is a simplified diagrammatic view illustrating
the pressure source 70, the cartridge 66, and the reservoir
110A and pressure chamber 110B. During idle periods, the
region between the reservoir bag and the pressure vessel is
allowed to de-pressurize. During shipping of the ink
35 container 110A, the supply is not pressurized.

The scanning carriage 52 and print cartridges 60-66 are controlled by the printer controller 80, which includes the printer firmware and microprocessor. The controller 80 thus controls the scanning carriage drive system and the
5 the print heads on the print cartridge to selectively energize the print heads, to cause ink droplets to be ejected in a controlled fashion onto the print medium 40.

The system 50 typically receives printing jobs and commands from a computer work station or personal computer
10 82, which includes a CPU 82A and a printer driver 82B for interfacing to the printing system 50. The work station further includes a monitor 84.

FIG. 3 shows in isometric view an exemplary form of a large scale format printer/plotter system 50, wherein four
15 off-carriage ink containers 110, 112, 114, 116 are shown in place in the ink supply station. The system includes a housing 54, a front control panel 56 which provides user control switches, and a media output slot 58 through which the media is output from the system after the printing
20 operation. This exemplary system is fed from a media roll; alternatively sheet fed systems can also be used.

Overview of the Invention

Aspects of the invention are illustrated in a general
25 sense in the simplified diagrammatic views of FIGS. 4, 5A and 5B. One aspect of this invention concerns an ink container employed at the ink supply station 100, having a pressure vessel 1102 surrounding a collapsible reservoir 114 containing a supply of ink and a sensor circuit 1170
30 that can provides a signal indicative of the volume of the ink in the collapsible reservoir. Leads 1142, 1144 for connecting to the sensor circuitry are electrically accessible at contacts (indicated generally as 1138 in FIG. 4) on the outside of the container. To achieve this, the
35 leads are routed from the contacts on the outside and to

the sensor circuitry on the inside of the pressure vessel. The leads pass through a sealing zone 20 separating an outside atmosphere from the pressurized region between the pressure vessel and the collapsible reservoir. Advantages of the system include directly sensing the bag position, which is more accurate than other methods such as measuring ink resistivity, that depends on ink properties. Moreover, the sensor is out of contact with the ink; thus, it will not be corroded by ink. In a preferred embodiment, the sealing zone is provided by a resilient member under compression and acting as a gasket. This preferred embodiment has manufacturing and reliability advantages.

As shown in FIG. 4, a second aspect of the invention involves a chassis 1120 that offers functional and manufacturing advantages for the ink container. Ink container 110 has leading and trailing ends relative to a direction of installation of ink container 110 into supply station 100. The chassis includes a tower shaped air inlet 1108 for receiving pressurized air from a printing system and a tower shaped ink outlet 1110 for delivering pressurized ink to the system. The air inlet and ink outlet, accessible on the leading edge of the container 110, extend approximately equal distances beyond an exterior surface of the ink container 110. The ink outlet is in fluid communication with collapsible reservoir 114. In a preferred embodiment, the chassis includes an attach surface 1122 to be received in an opening 114A of the collapsible reservoir. This attach surface allows a volumetrically efficient pleated bag construction to be used for collapsible reservoir 114, by providing a surface whose normal is substantially parallel to the long axis of the bag. The chassis, in combination with a separate housing 1102, provides a pressure vessel that surrounds the collapsible reservoir 114. In an exemplary form, the housing 1102 is a bottle shaped structure with an opening for receiving a peripheral

surface of the chassis. The chassis provides a surface for container electrical contacts associated with the printing system. The chassis provides a surface for routing an electrical pathway such as pathways 1156, 1158 between the sensor and some of the container electrical contacts 1138.

In a preferred embodiment, the chassis provides all of this functionality with a single integral part. Using an integral part improves manufacturability and relative locational accuracy of the parts included in the chassis.

As shown in FIGS. 5A and 5B, a third aspect of the invention concerns at least one separately attached cap that provides mechanical functions. In a preferred embodiment, two caps 1104, 1106 are separately attached to the pressure vessel 1102. With this preferred embodiment, the mechanical functions include, for a trailing end cap, (i) latch features 1232 for securing the ink container 110 into supply station 100, and (ii) an oversized end 1106A that prevents backwards insertion of the ink container into the supply station. For a leading end cap, the mechanical functions include (i) a boss 1258 for protecting the container interconnects, (ii) keying features to assure that the ink container 110 is installed in the proper ink supply station location, and (iii) aligning features to assure proper positioning of the ink container into the supply station. By providing all of these functions on one or more end caps, the pressure vessel configuration can be simplified, and designed without any of the foregoing mechanical functional requirements.

A Preferred Embodiment of The Ink Container

An exemplary embodiment of the ink containers 110-116 is now described with reference to FIGS. 6-28; only one container need be described, since all the containers are identical, except for keying features on a cap described

below. In general, the container is an assembly of a pressure vessel defining a pressure chamber, a collapsible ink reservoir including a flaccid bag, an ink level sensing (ILS) circuit, a multi-function chassis element to which the bag is sealed, the chassis providing an ink pathway from an outlet port to the reservoir and an air inlet port and pathway leading to a region of the pressure chamber outside the reservoir, and leading end and trailing end caps.

The Pressure Vessel. In an exemplary embodiment, the pressure vessel 1102 is a bottle-shaped structure having a neck region through which an opening extends to the interior of the vessel. One suitable method for fabricating the vessel at low cost is a combined blow-molding and injection molding process, wherein relatively higher tolerances are obtained for interior peripheral surfaces at the neck region of the vessel, and relatively low tolerances for the remainder of the vessel. An exemplary material suitable for the vessel in high-volume applications is polyethylene, injection-blow-molding grade; a typical thickness of the material for the vessel is 2 mm.

The pressure vessel 1102 is shown in the broken side view of FIG. 8, with the air tower 1108 and ink tower 1110 which are defined by a chassis member, secured in place by a crimp ring 1280, as will be discussed below. Here, the neck region 1102A of the vessel appears, defining an inner peripheral neck surface of the pressure vessel.

The exterior of the neck region includes physical features for securing the internal ink container within the pressure vessel, and for securing a leading end cap. These features include a plurality of flanges (1252A-1252C) formed in the external surface of the neck region.

The volume of the interior pressure chamber of the vessel will be dependent on the desired ink capacity of the ink container. Products of different ink capacity can be

provided by use of pressure vessels having a similar cross-sectional configuration, but with different vessel lengths in a direction along the longitudinal axis of the container, and with corresponding differences in the size of the ink reservoir bag. In an exemplary application, the vessel profile is 50 mm by 100 mm, with the vessel length a function of the container supply capacity. Exemplary ink capacities for different products are 350 cc and 750 cc. Inks of different colors and ink types can be stored in the ink containers, for use in the color printing systems as shown in FIG. 1. The vessel structure need not change to accommodate different ink colors or types. During manufacture, inventory and mold costs are managed by employing the same pressure vessel for the various ink types and colors.

While the pressure vessel 1102 illustrated in the drawings has a rectangular cross-section, it is to be understood that other vessel configurations can also be employed, such as cylindrical.

The Ink Reservoir. The ink reservoir for the ink container in this embodiment is provided by a flaccid bag, which in an ink-filled state substantially occupies the open volume within the pressure vessel. FIG. 10 illustrates the collapsible liquid ink reservoir 114 surrounded by the pressure vessel 1102. In one implementation, an elongated sheet of the bag material is folded such that opposed lateral edges of the sheet overlap or are brought together, forming an elongated cylinder. These lateral edges are sealed together. Pleats are formed in this resulting structure, and the bottom of the reservoir bag is formed by heat sealing the pleated cylinder along a seam transverse to the seal of the lateral edges. The top of the reservoir bag is formed in a similar fashion, while leaving an opening for the bag to be sealed to the chassis member. In an exemplary embodiment, the bag material is a multilayered sheet, fabricated of polyethylene, metalized

polyester and nylon. Rigid bag stiffener elements 1134, 1136 are attached respectively to the outside of the flexible bag of the reservoir, i.e. on opposite wall side portions 1114, 1116 of the reservoir. The stiffeners improve the repeatability of collapse geometry of the sides of the bag so that the ink level sensing signal provided by the ink level sensor has improved repeatability.

Ink Level Sensing Circuit. The ink level sensing circuit includes inductive coils 1130 and 1132 formed on flexible circuit substrate portions disposed on the opposing side wall portions of the reservoir bag. An AC signal is passed through one coil, inducing a voltage in the other coil whose magnitude varies as the wall separation distance varies. As ink is used, the opposing side wall portions 1114, 1116 collapse together, changing the electrical or electromagnetic coupling, e.g. mutual inductance, of the coil pair. This change in coupling is sensed by the printing system, which thereby infers an ink level.

The coils 1130, 1132 are connected to contact pads 1138, 1140 that are accessible on the outside of the sealed container (FIGS. 6 and 9). Flexible circuit leads 1142, 1144 respectively connect these ink level sensing pads to the coils 1130, 1132; these leads run through a seal zone that separates an outside atmosphere from the pressure chamber. More specifically, each pair of pads 1138A, 1138B and 1140A, 1140B provides an independent pair of connections for each of the two opposing coils. This allows an excitation signal to be applied to one coil, and the corresponding voltage resulting from the electrical coupling to be sensed by the printing system. The voltage sensed by the ILS circuit is readily related to a corresponding ink level, e.g. by values stored in lookup tables in the system memory.

FIGS. 13 and 16A show the unitary flexible circuit 1170 carrying the ILS leads and ILS coils. Each pair of

ILS pads 1138A/B, 1140A/B (on either side of the memory element contacts 1172A, 1172B, when assembled to the chassis) provides contact for one coil. A jumper connects the center of each coil to its one of the leads in order to complete the circuit. This is shown in FIG. 13, wherein coil 1130 has a jumper 1174 connecting from lead 1176 to the coil center terminal 1178. Of course, a layer of insulator 1180 is required to insulate the jumper 1174 from the underlying conductor to prevent shorting the coil. The leads 1176 and 1182 and coil 1130 are formed on a flexible dielectric substrate 1182. A unitary substrate can be used for supporting the coils and leads for both sides of the bag, as shown in FIG. 16A. The leads and substrate can be folded adjacent the right angles to bring the coils into position for attachment to the bag sides. The ILS is described more fully in the above referenced applications, Docket number 10970427, INK CONTAINER WITH AN INDUCTIVE INK LEVEL SENSE, and Docket number 10970428, INK LEVEL ESTIMATION USING DROP COUNT AND INK LEVEL SENSE.

The Chassis Member. An aspect of the invention is a multi-functional chassis member 1120 that enables an ink container having a high degree of functionality while having an efficient assembly process. This part supports the air inlet, fluid outlet, the collapsible ink reservoir, the ink level sensing (ILS) circuitry, ILS trace routing, and provides the surface that seals the pressure vessel from the outside atmosphere.

In an exemplary embodiment, the chassis member 1120 is a unitary element, fabricated of polyethylene by injection molding. The material is chosen to be one which is relatively low cost, chemically inert to the liquid ink, and similar to the layer of the bag material which is heat sealed to the chassis. Another desirable characteristic of the chassis material is that the material is heat stakable

at relatively low temperatures. The chassis is injection molded to allow high complexity at a low cost.

As shown in FIG. 10, the pressure vessel 1102 surrounds the collapsible ink reservoir 1112. The reservoir plastic film is folded and heat sealed along edges and sealed to stake or attach surfaces 1122 and 1124 on the chassis 1120, to form the flexible walls 1114 and 1116.

As shown in FIG. 11, the chassis 1120 further provides air inlet and fluid outlet septum towers 1108, 1110, respectively. The air inlet tower 1108 defines a passageway 1200 through the chassis that is in fluid communication with a region of the pressure chamber which is outside the reservoir 1112 (FIGS. 11 and 14). The fluid outlet tower 1110 defines a passageway 1202 through the chassis member that is in fluid communication with the internal collapsible reservoir 1112. The towers extend in a direction generally parallel to the longitudinal axis of the container, in this exemplary embodiment.

Upon installation of the chassis 1120 in the pressure vessel opening, the towers 1108 and 1110 protrude above the opening end of the pressure vessel. With their extension above the surface 1204 of the chassis, and above the neck of the pressure vessel, the towers are accessible for connection with an ink path connection and an air supply connection when the ink container is installed in its bay at the ink supply station of the printing system. The connection of the ink path and air supply is described more fully in the above referenced application, Docket number 10970426, entitled REPLACEABLE INK CONTAINER ADAPTED TO FORM RELIABLE FLUID, AIR AND ELECTRICAL CONNECTION TO A PRINTING SYSTEM.

The chassis 1120 also provides a flat surface 1204 for supporting a memory element chip package 1206 (FIG. 9) and the two pairs of leads connecting to the inductive coils for sensing ink level described in additional detail below.

The memory chip has its own small circuit panel with four electrical contacts, and is connected to the system controller when the ink container is installed at the supply station. The circuit for the memory chip is attached to the surface 1204 by pressure sensitive adhesive. The controller can write data into the memory, e.g., to identify the current ink volume remaining. Thus, even if a container is removed from the supply station prior to being emptied of ink, and subsequently placed in use, the printing system controller can ascertain the amount of ink already used from the container. In addition to supporting the memory element, the chassis 1120 provides an upstanding member 1208 (FIG. 14) that engages surfaces on a mating electrical connector (which is located at the ink supply station bay) to provide alignment between both sides of the electrical connection. This connector makes simultaneous face-type connection with all 8 pads, i.e. 4 pads for the memory element and two pairs of pads for the inductive coils.

The chassis member 1120 includes a keel portion 1292, which provides the sealing or attach surfaces 1122, 1124 for connection to the collapsible reservoir (FIG. 11). The bag membranes can be sealed to the sealing surfaces in a variety of ways, e.g. by heat staking, adhesives or ultrasonic welding. In an exemplary embodiment, the bag membranes are attached by heat staking. The lower surface 1294 of the keel has a compound curvature to prevent concentration of stress should the ink container be dropped. Also, protruding tab features 1296 around the inlet to the ink flow path serve to prevent the bag collapse from sealing off the inlet before all ink is removed from the reservoir. Due to the elongation of the keel, the sealing surfaces extend generally parallel, with a small angular offset, relative to the longitudinal axis of the ink container.

The chassis sealing surfaces have protruding ribs extending therefrom to improve the quality of the seal. These ribs, e.g. ribs 1282, 1284, 1286 (FIG. 15) extend generally transverse to the longitudinal axis of the reservoir. The ribs concentrate the heat staker force during the heat staking operation to attach the bag films to improve the heat stake attachment. The spaces between the ribs also provide space for molten chassis material to flow during the heat stake. Multiple ribs are provided to provide redundant attach features and strength.

FIG. 14 shows the chassis prior to attachment of the septa 1214 and 1216. As shown in FIG. 11, septa 1214 and 1216 are secured at the respective ends of the towers 1108 and 1110 by crimp caps 1218, 1220. For the ink outlet, a spring 1222 presses a sealing ball 1224 against the septum 1216. This is because the ink seal is critical; if the septum 1216 takes on a compression set, it is important that the fluid outlet not leak. In contrast, the air inlet can take on a set without an issue, and so in this exemplary embodiment, no additional sealing structure is employed.

The routing of ILS leads or traces 1148, 1150 from the contact pads 1138A, 1138B, and 1140B and 1140B toward the ILS coils 1130, 1132 is illustrated in FIGS. 9, 10, 14 and 15. The chassis 1120 supports the flexible circuit portions 1148 and 1150; an o-ring seal 1152 provides a seal between the chassis periphery and the neck 1154 of the bottle-shaped pressure vessel 1104. As shown in FIGS. 10, 14 and 15, respective routing surfaces 1156, 1158 are provided in the chassis 1120 for routing the ILS flexible circuit traces 1148, 1150 between the o-ring 1152 and the chassis. FIG. 10 shows the flat zones 1160, 1162 formed on the interior surface of the neck 1154 of the pressure vessel to match the flat portions of the routing surface 1156, 1158.

There are alternatives to this routing scheme. For example, an adhesive could be used to complete the seal zone through which the leads pass. However, this would require steps of curing adhesive, making this alternative less manufacturable. In addition, adhesives tend to be less robust than a compressed o-ring.

The chassis 1120 defines a circumferential channel 1226 (FIGS. 11, 14, 15) that supports the o-ring 1228 providing a seal between the chassis and the pressure vessel. As described above, the chassis 1120 also provides flexible circuit routing surfaces 1156, 1158 for the flexible circuit 1170 to pass from the flat outside surface 1204 of the chassis, between the o-ring and the flex routing surface, and into the pressure vessel. The pressure vessel has an inside surface whose shape matches an outside surface on the chassis. Portions of the chassis are flat, for routing the flexible circuit traces; the vessel has flat portions or zones 1160, 1162 to match the flat portions of the chassis.

In an exemplary embodiment, the o-ring material is a relatively stiff material such as EPDM, silicon rubber, or neoprene, having a 70 shore-A hardness. Enhancement of the seal in the area of the ILS lead pathways, i.e. where the o-ring passes over the flexible circuit, is obtained using such a stiff material because it works in combination with a pressure sensitive adhesive used to attach the ILS leads. The firm o-ring material is believed to squeeze the adhesive out around the edges of the ILS leads, and fill small discontinuity cavities adjacent to these edges. The underside of the flexible circuit 1170 has a coating of pressure-sensitive adhesive underlying specific areas of the flexible circuit. Adhesive underlies the coils and areas which will come into contact with the chassis member. The adhesive is thus used to attach the coils to the stiffeners on the reservoir walls, and to attach the ILS

flexible circuit to the chassis member 1120. FIG. 16B is an isometric view of the collapsible reservoir 114, attached to the chassis 1120, with the ILS flexible circuit attached to the reservoir and to the chassis.

5 Once the reservoir bag is attached to the chassis, and the coils 1130, 1132 are attached to the collapsible walls 1114, 1116, the reservoir assembly is inserted into the pressure chamber through the vessel opening. The o-ring provides a seal fit against the interior surface 1162 of
10 the pressure vessel. An aluminum crimp ring 1280 (FIG. 10) is installed to secure the chassis 1120 and reservoir structure in place.

 The chassis 1120 is an integrally molded thermoplastic part, providing an o-ring support and sealing surface 1226,
15 routing surfaces 1156, 1158 for ILS traces, two septum towers 1108, 1110 and their respective communicating conduits 1200, 1202, a surface 1204 for supporting electrical interconnection, the upstanding member 1208, and support and sealing surfaces 1210, 1212 for the collapsible
20 bag. By offering so much functionality on one molded part, the overall cost of the containers 110-116 is minimized and additional sealing mechanisms are avoided. Another advantage of an integrally molded chassis is dimensional accuracy. When ink container 110 is installed into a printing
25 system, the electrical, air and fluidic connectors must engage corresponding connectors associated with the printing system at the ink supply station 100. The integrally molded chassis minimizes locational variation of these connectors relative to one another and thus improves the
30 likelihood of providing reliable connections.

The leading end cap. The end cap 1104 provides several functions. These include keying functions for preventing insertion of an ink container of the wrong type, e.g the wrong ink type or color, or ink reservoir size,
35 into a particular supply station bay. The cap also serves

aligning functions in ensuring proper alignment of an ink container with the supply station bay structural components. The cap also includes protective structure which protects the ink and air towers of the chassis from physical damage.

In an exemplary embodiment, the leading end cap 1104 is an injection-molded part, fabricated from polypropylene.

As shown in FIG. 5A, with additional details in FIGS. 19 and 23, the leading end cap 1104 is secured onto the neck of the pressure vessel by engagement of locking features on the cap and the neck region of the pressure vessel. Thus, the cap 1104 includes a cylindrical engagement structure 1244 (FIGS. 19, 23) with two pairs 1246A, 1246B of inwardly protruding engagement surfaces for engaging corresponding a flange 1252B of the neck of the pressure vessel to secure the cap 1104 into registered position on the pressure vessel. The surfaces 1246A, 1246B are spaced around the periphery of the engagement structure 1244. Each engagement surface 1246A, 1246B includes a ramp surface 1248A, 1246B for riding over the flange 1252B as the cap is pressed onto the neck of the pressure vessel.

As shown in FIG. 28, with additional details shown, e.g. in FIG. 17, the transverse end (in relation to the longitudinal axis of the container) of the cap 1104 further includes a flat surface 1256 into which openings 1254 is formed. Surrounding the opening 1254 is a key-shaped boss or wall structure 1258. The wall structure 1258 provides a protective wall around the towers 1108 and 1110 and electrical interconnect contacts after installation of the cap, thereby protecting these components from physical damage. Moreover, the underside of the flat surface 1256 provides a stop surface against which the rim of the pressure vessel registers as the cap 1104 is pressed on. Once the surfaces 1246 have engaged the vessel rim 1250, the cap is securely locked into position on the pressure

vessel, and cannot be removed without breaking the locking features.

As shown in FIGS. 6 and 28, respective keying and aligning features 1240 and 1242 are provided at opposite sides of the leading cap 1104. These features prevent major ink incompatibilities. By their asymmetry, they prevent backwards insertion (180 degree) installation in the ink supply station relative to a direction of installation. In a preferred embodiment, feature set 1240 is a variable feature for defining the color of the ink disposed in the container reservoir. This is achieved by the geometry of the feature 1240. FIG. 24 illustrates six possible cap/feature configurations. Cap 1104-1 employs color identifying feature 1240A, which specifies the color yellow in this case. Similarly, cap 1104-2 employs feature 1240B (magenta), cap 1104-3 employs feature 1240C (cyan), cap 1104-4 employs feature 1240D (black), cap 1104-5 employs feature 1104-5 (first other color), and cap 1104-6 employs feature 1240F. Each ink supply station bay has provided therein corresponding features which permit only an ink container with the proper color feature set to be docked at the bay. The interaction of the corresponding features on the cap and the supply station bay further provide aligning functions to properly align the cap and container with the bay. This increases the reliability of the ink, pressurized air system and electrical connections made between the ink supply station bay and the ink container.

The second keying features 1242 are also employed to provide keying and identifying functions. The features 1242 comprise a set of thin fins protruding from the side of the cap. The number of fins and spacing between the fins represent a code identifying product type, which can include type of ink, reservoir capacity, and the like. Here again, each ink supply station bay has provided

therein corresponding features which permit only an ink container with the proper product type feature set to be fully inserted into a bay for mating connection to the ink system. This will prevent contamination of the system with improper ink types, for example. Also, the features 1242 provide aligning functions, in the same manner as described above with respect to features 1240.

FIG. 25 represents several different possible configurations of the feature set 1242, showing feature sets 1242A-1242F for different configurations of caps 1104-7 to 1104-12.

As with the feature 1240, the ink supply station bay is provided with keying features which correspond to the feature 1242, preventing insertion of an ink container which does not have the corresponding key feature, preventing docking of an ink container of the wrong product type in a given supply station bay.

It will be appreciated that a set of caps can have identical features 1242, representing a particular product type, while having different features 1240, representing different ink colors for containers of the same product type.

The Trailing End Cap. As shown in FIGS. 8 and 9, the trailing end cap 1106 provides a plurality of mechanical functions. The trailing cap 1106 provides an enlarged head to prevent backward insertion in the ink supply station 100. In addition, the trailing cap provides latch surfaces 1230 and 1232 (FIG. 6) which engage corresponding features at the ink supply station when the container is docked to secure the container in a latched position, as is described more fully in the above referenced co-pending application entitled METHOD AND APPARATUS FOR SECURING AN INK CONTAINER, attorney docket 10970424. These supply station features are generally illustrated in FIG. 22 as features 1270.

The trailing cap is attached to the pressure vessel in this exemplary embodiment by adhesive. This is illustrated in FIGS. 20 and 21. The trailing end of the pressure vessel is reduced in width dimension, and the cap 1106 is appropriately sized to fit over the reduced size end of the vessel (FIG. 21). The cap 1106 is secured in place by a layer 1290 of adhesive, in this exemplary embodiment.

The trailing cap includes all of the user-viewable surfaces of the container when it is inserted into the ink supply station bay. For this exemplary embodiment, only surface 1106B (FIG. 22) is visible when the container is inserted into the bay. The advantage of this feature is that stringent cosmetic requirements for a consumer product such as the ink container are limited to a single part (i.e. the cap 1106) of limited surface area. Another advantage is that the trailing cap 1106 is added at the end of the assembly process, so that it will not be marred or scratched during preceding steps of the assembly.

Another feature of the trailing end cap is a visible color indicia swatch or element 1288, on the end surface 1106B. This swatch is a visual indication of the color of the ink disposed within the container, and matches a corresponding swatch 1002 disposed on the housing for the supply station bay, as shown in FIG. 22. The swatches 1288 and 1002 can be labels adhesively attached, in one exemplary embodiment. Alternatively the elements 1288, 1002 can be text describing the color.

Assembly of the Ink Container. The ink container can be assembled in a highly efficient manner, as a result of the multiple functions provided by the chassis member. With efficient assembly, the cost can be minimized, and the reliability of the finished product is improved.

FIG. 26 is a flow chart showing illustrative steps in the assembly of an ink container in accordance with the invention. First, a chassis element 1120 and reservoir bag

having an open end are provided (step 1502). The open end of the bag is then sealed to the keel of the chassis member by a heat staking process (step 1504), and the bag/chassis assembly is tested for leaks (step 1508). The ILS flexible circuit is now attached to the flat chassis surface 1204, using the pressure sensitive adhesive applied to the corresponding surface region of the circuit substrate (step 1510). After attachment of the ILS circuit at the surface 1204, the ILS flexible circuit is bent to follow the electrical pathways 1156, 1158 provided by the chassis member 1120, and the coils and stiffeners are attached to the side walls of the bag, again with pressure sensitive adhesive (step 1512).

After the ILS circuit is attached, the o-ring 1152 is stretched over the front of the chassis member, and placed in its channel provided by the chassis member (step 1514).

The reservoir bag of the chassis/bag/ILS sub-assembly is now folded into a C-shape to facilitate the insertion of the sub-assembly into a pressure vessel (step 1516). A pressure vessel with a leading end opening is provided (step 1518), and the chassis/bag/ILS sub-assembly is fully inserted into the pressure vessel through the opening (step 1520). FIG. 27 indicates the insertion of the chassis/bag/ILS sub-assembly into the opening of the pressure vessel 1102. After insertion of the sub-assembly into the pressure vessel, an aluminum crimp ring 1280 is installed to secure the chassis in the inserted position (step 1522). The ring is crimped over the top flange 1252A of the vessel. The memory chip package is attached to the chassis (step 1524).

At this point, the ink reservoir is completely assembled within the pressure vessel, and there remains only the tasks of attaching the leading and trailing end caps 1104, 1106. FIG. 28 shows the assembled pressure vessel and ink container, in exploded view with the caps 1104, 1106.

The leading and trailing caps are attached to the pressure vessel (step 1526) in the manner described above. The reservoir is filled with ink through the ink tower passageway (step 1528) to complete the assembly process.

5 An ink container and assembly method have been described which provides many advantages. The ink container supports high ink flow rates, e.g. for large format printing and plotting applications, high speed color copiers, line printer, etc. The risk of a severe ink leak is
10 greatly reduced because the flaccid bag ink reservoir is contained within the air tight pressure vessel. The number of hermetic seals is reduced, due to the multi-function chassis member. The ink level within the container can be
15 sensed through the use of the inductive coils and ink level sensing circuits. Top down assembly of the container is achieved. The reliability of the ink container is very high. Water vapor loss through diffusion from an external
20 environment into the ink reservoir is reduced because the region between the flaccid bag and the pressure vessel becomes humidified. Ink can be withdrawn from the reservoir with the container in any orientation. The containers
25 do not need to have an integral air or ink pump, and so an array of throughput needs can be met by the ink container. Stresses due to pressurization on the flaccid bag are reduced since forces are balanced across the bag area when
30 compared to pressurization systems that press on the bag film, such as spring bag systems. Pressure drops through the system are relatively low. The ink reservoir can be filled with ink through the same ink port used to connect
35 to the system, and so an extra fill port is not needed.

 It is understood that the above-described embodiments are merely illustrative of the possible specific embodiments which may represent principles of the present invention. Other arrangements may readily be devised in accordance with these principles by those skilled in the art

without departing from the scope and spirit of the invention.

CLAIMSWhat is claimed is:

1. An ink container for holding a pressurized supply of ink, comprising:

a pressure vessel (1102) for defining an interior pressurized chamber;

5 a collapsible ink reservoir (114) for holding a supply of liquid ink, said reservoir disposed within said pressurized chamber;

electrical circuitry (1170) attached to the collapsible ink reservoir for providing electrical
10 signals indicative of an amount of ink within the reservoir, said circuitry including conductive leads (1142, 1144) passing from the chamber through a vessel opening for connection to a sensor controller;

apparatus (1110) for providing an ink path (1202)
15 from the exterior of said pressure vessel to said ink reservoir;

apparatus (1120) for providing a seal around the conductive leads and ink path to maintain an air pressure within said pressure chamber which is higher
20 than ambient pressure.

2. The container of Claim 1 further comprising apparatus (1108) for providing an air inlet path (1200) through said vessel and communicating with the pressurized chamber for connection to a supply (70) of pressurized gas
5 to maintain said pressurized chamber air pressure.

3. The container of Claim 2 wherein said air inlet path (1108) extends through said pressure vessel opening.

4. The container of any preceding claim wherein said pressure vessel (1102) is a unitary enclosure member, and said opening is the only opening defined in the enclosure member.

5. The container of any preceding claim, further comprising a supply of liquid ink disposed within the collapsible ink reservoir (114).

6. The container of any preceding claim wherein the apparatus for providing a seal includes a compressible member (1152).

7. The container of Claim 6 wherein the compressible member (1152) includes an o-ring fabricated of a resilient material.

8. The container of any preceding claim wherein the collapsible ink reservoir (114) includes a first flexible wall portion (1114) and a second flexible wall portion (1116), wherein said wall portions collapse toward each other as ink is depleted from the reservoir, and wherein the electrical circuitry (1170) includes a first conductive coil (1130) attached to an exterior of the first wall portion, a second conductive coil (1132) attached to an exterior of the second wall portion, a first set of electrical leads (1142) attached to said first coil and passing through the vessel opening to a first set of electrical contact pads (1138A, 1138B), and a second set of electrical leads (1144) attached to the second coil and passing through the vessel opening to a second set of electrical contact pads (1140A, 1140B), said first set of electrical contact pads and said second set of electrical contact pads located outside of the pressurized chamber.

9. An ink container according to any preceding claim, further comprising an electrical pathway (1156) that electrically couples the electrical circuitry to the container contacts, the electrical pathway traversing a seal zone (20) that separates the pressurized region from the outside atmosphere.

5 10. An ink container according to Claim 9 wherein said ink container is installed in a first direction, said electrical pathway has a first segment connecting to said circuitry, said first segment substantially aligned with the first direction.

5 11. An ink container according to Claim 10, wherein the electrical pathway has a second segment that connects to the first segment, said second segment defining a right angle bend to allow said pathway to connect to the container contacts.

12. An ink container according to any of Claims 9, 10 or 11, wherein the electrical pathway is provided by a flexible circuit.

13. An ink container according to any preceding claim, wherein said opening includes a flat portion (1162) that provides a flat surface over which to route the electrical pathway.

14. An ink container according to any preceding claim, wherein the electrical signal is indicative of the degree of collapse of the reservoir.

15. An ink container according to any preceding claim, wherein the container is for an inkjet printing

system, the printing system having a printhead for ejecting ink on media.

5

16. An ink container according to any preceding claim, wherein said pressure vessel has a neck region that extends outward from said pressure vessel toward a distal end, and said opening is disposed at said distal end.

10

17. A method of assembling an ink container to be installed in an inkjet printing system, said inkjet printing system having a printhead for ejecting ink on media, comprising the steps of:

15

(a) providing (1502) a first housing member (1120) including a fluid pathway (1202) with a fluid outlet for providing ink to said printhead;

(b) fluidically coupling (1504) a collapsible reservoir (114) to said fluid outlet;

20

(c) attaching (1510) a plurality of container contacts on an outside surface of said first housing member;

(d) attaching (1512) an ink level sensing circuit (1170) to said collapsible reservoir;

25

(e) routing (1512) a plurality of electrical paths (1142, 1144) that couple said sensing circuit to said container contacts;

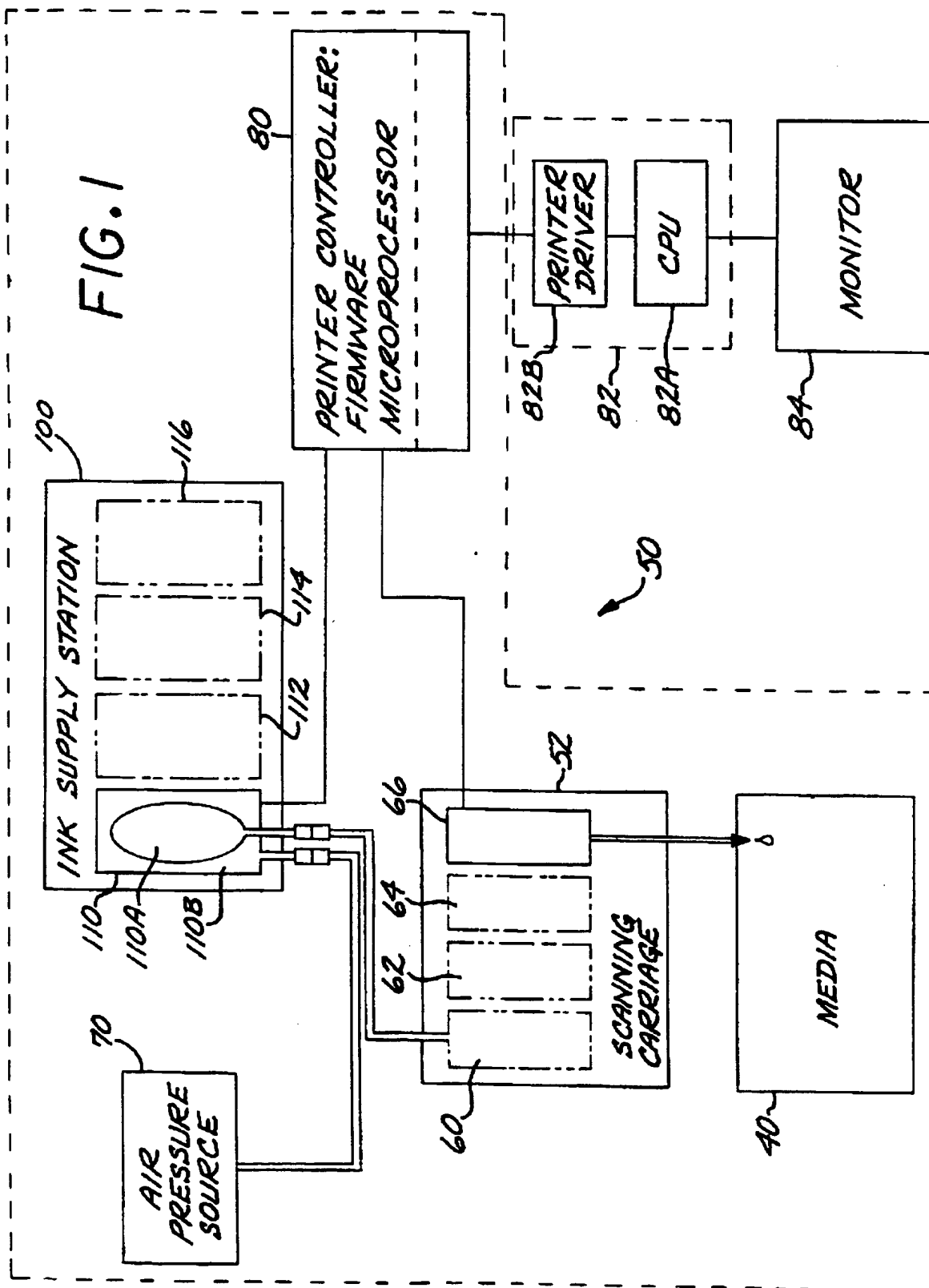
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(f) attaching a second housing member (1102) to said first housing member, said second housing member abutting said first housing member along a seal zone, said first and second housing members forming a pressure vessel that surrounds said collapsible reservoir, said pressure vessel and said collapsible reservoir defining a pressurized region therebetween, said plurality of electrical paths passing through said seal from said pressurized region to said outside atmosphere.

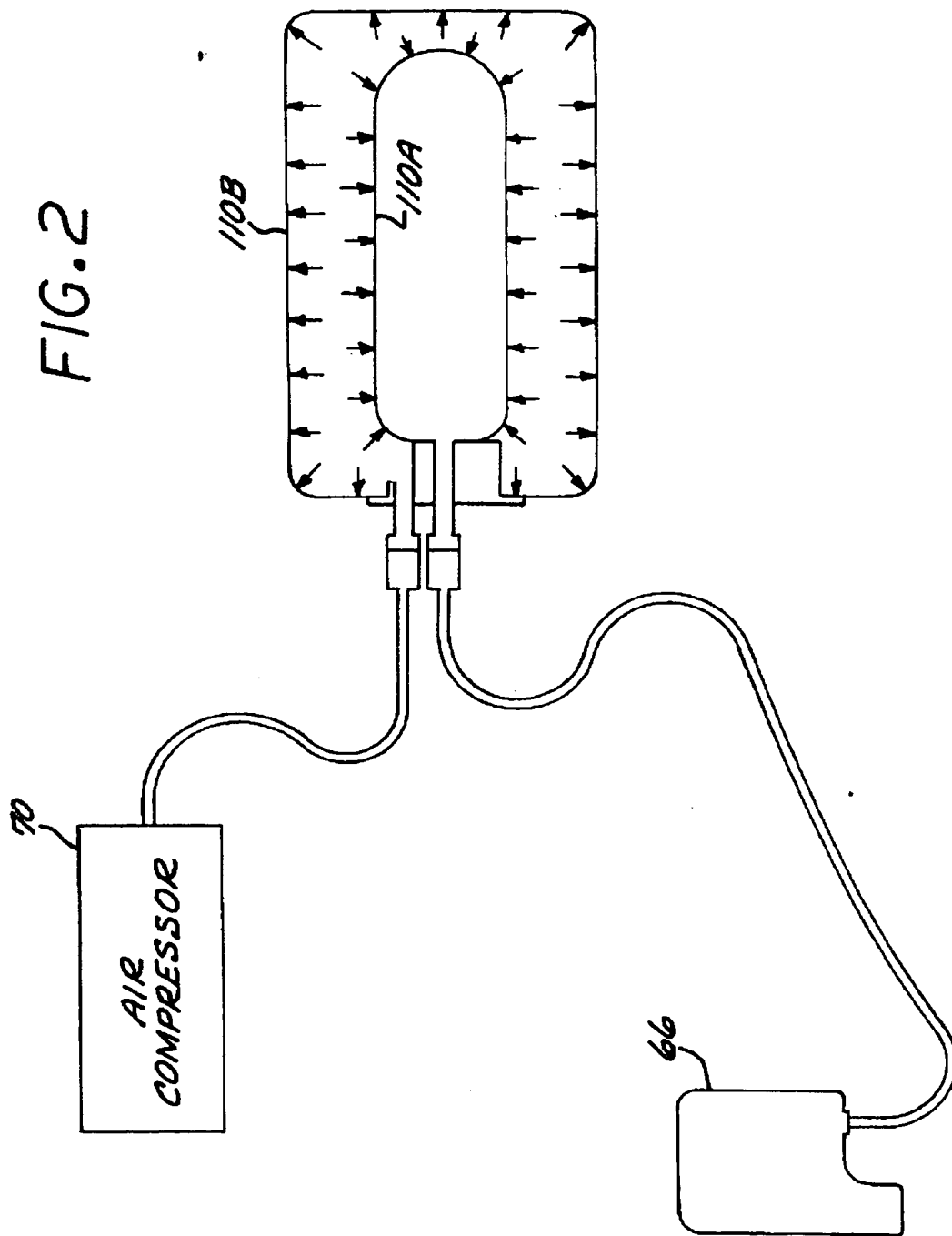
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18. The method of Claim 16 wherein said second housing member (1102) is a bottle-shaped member, having an opening at one end, and said collapsible reservoir (114) is received through said opening when said first housing member is attached to said second housing member.

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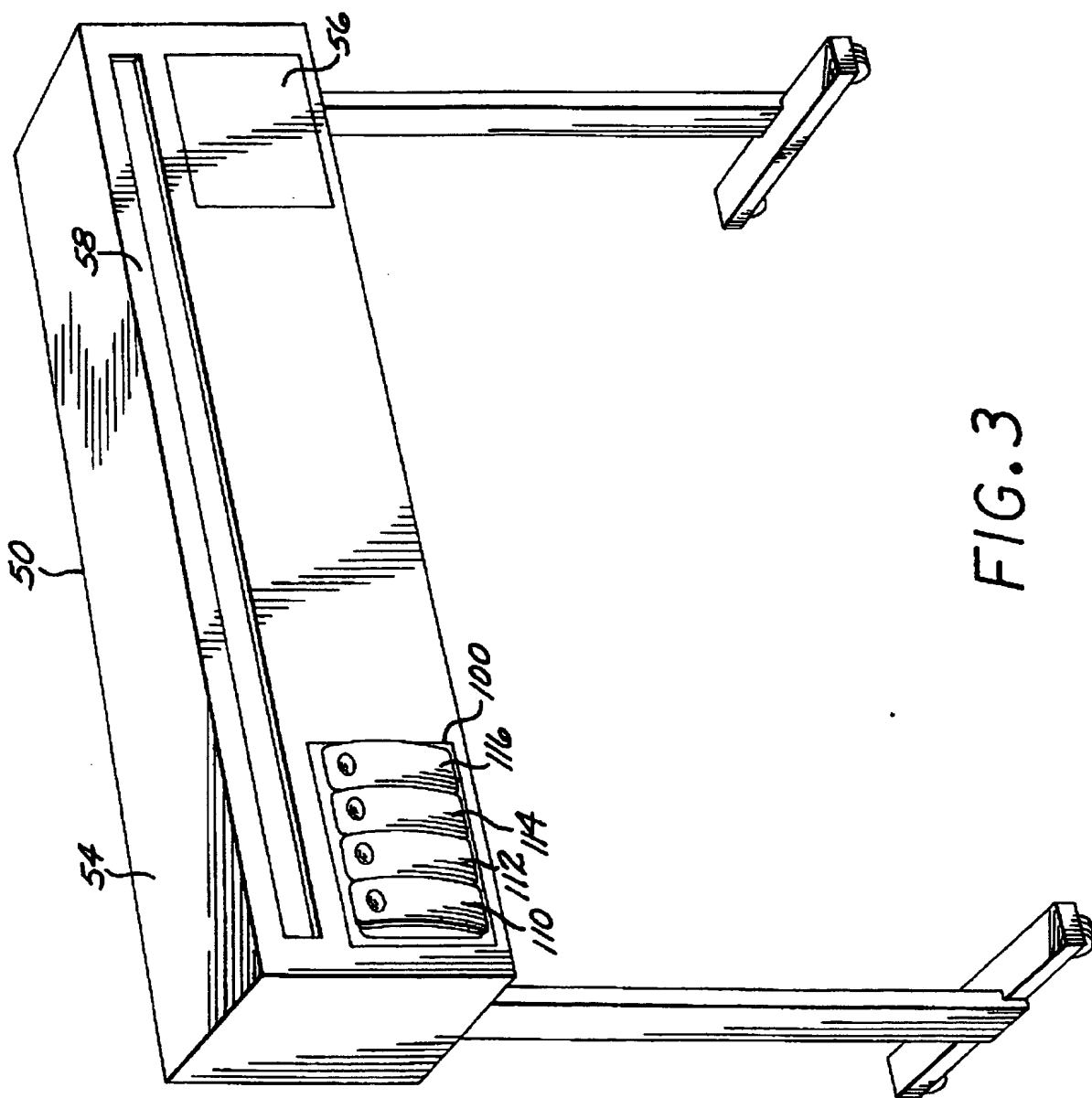
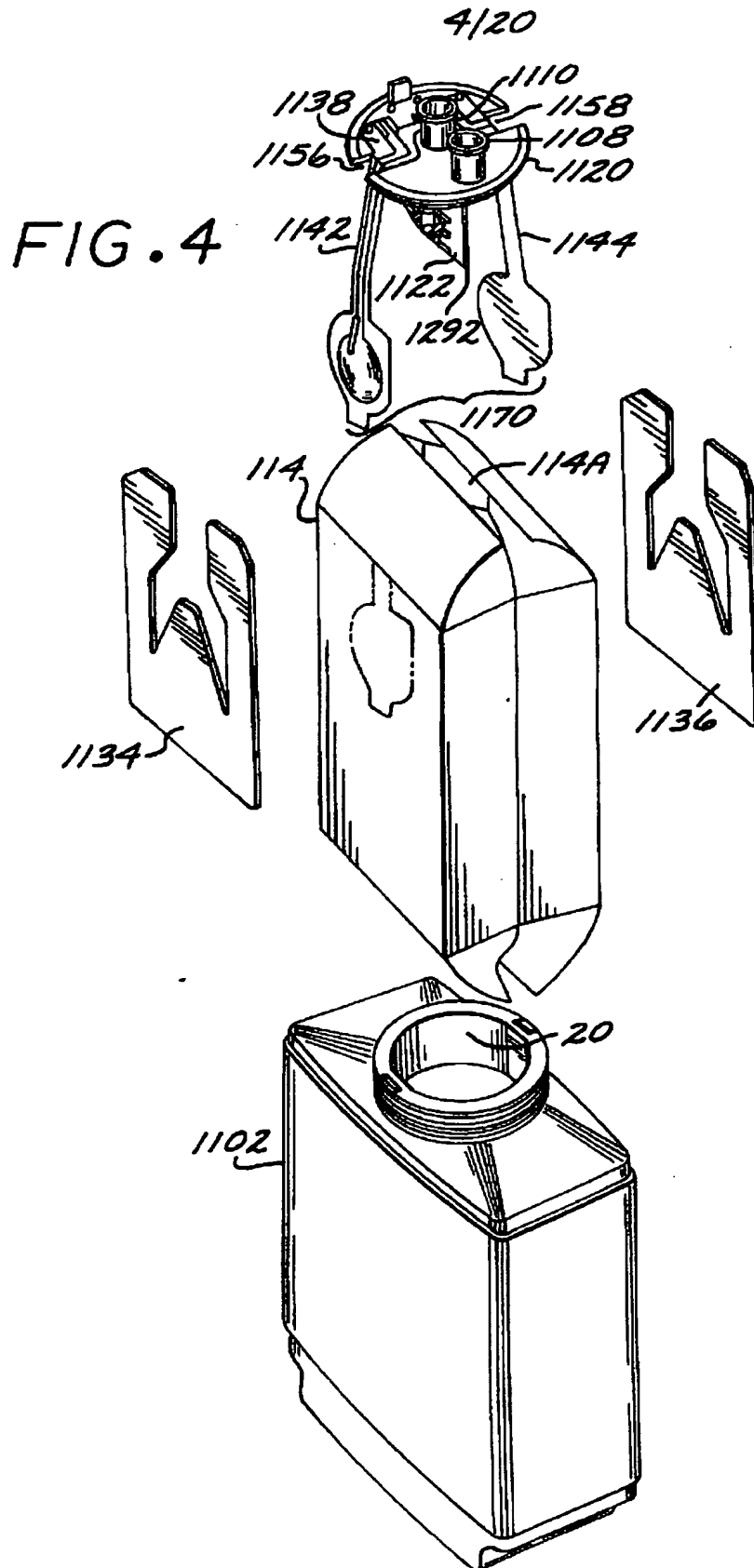
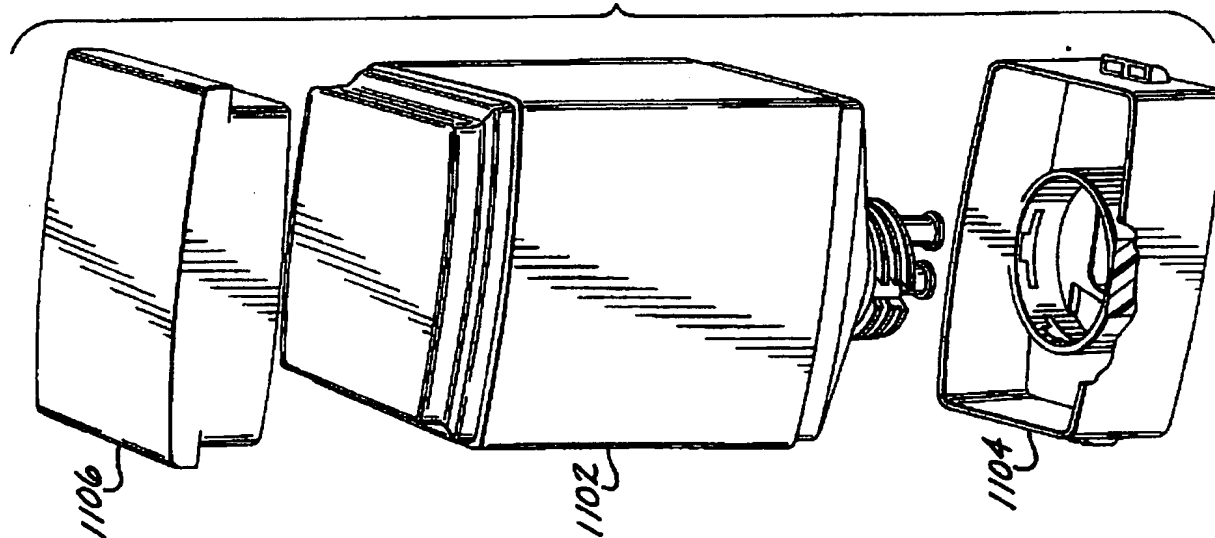
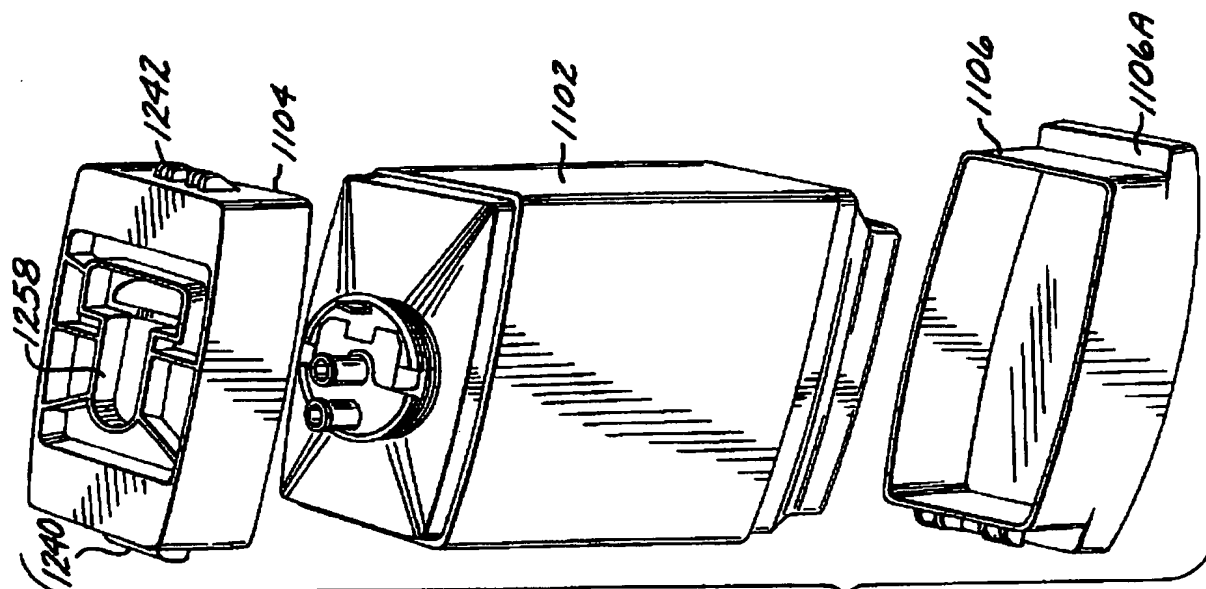


FIG. 3



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FIG. 6

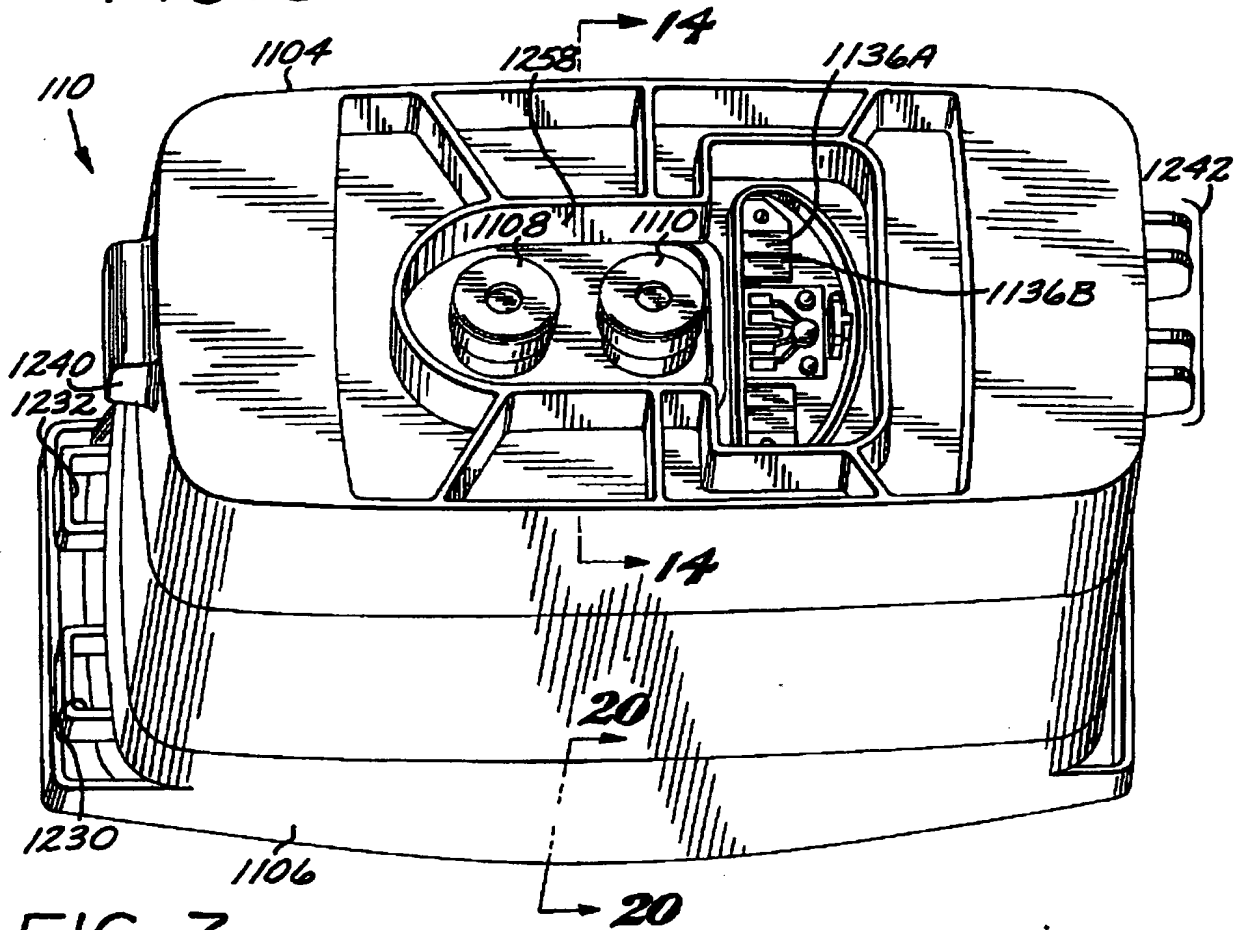
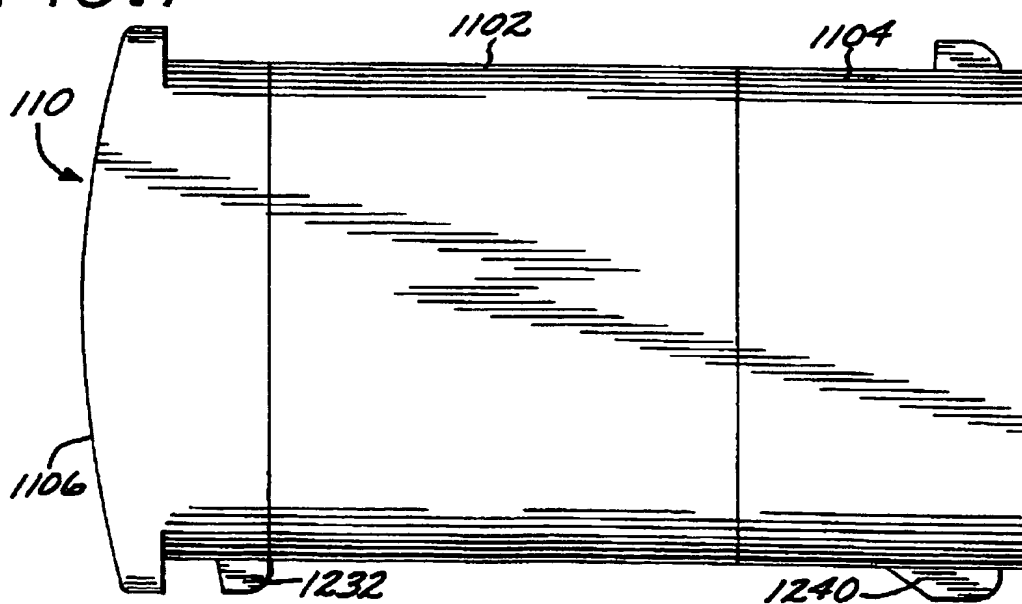


FIG. 7



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FIG. 8

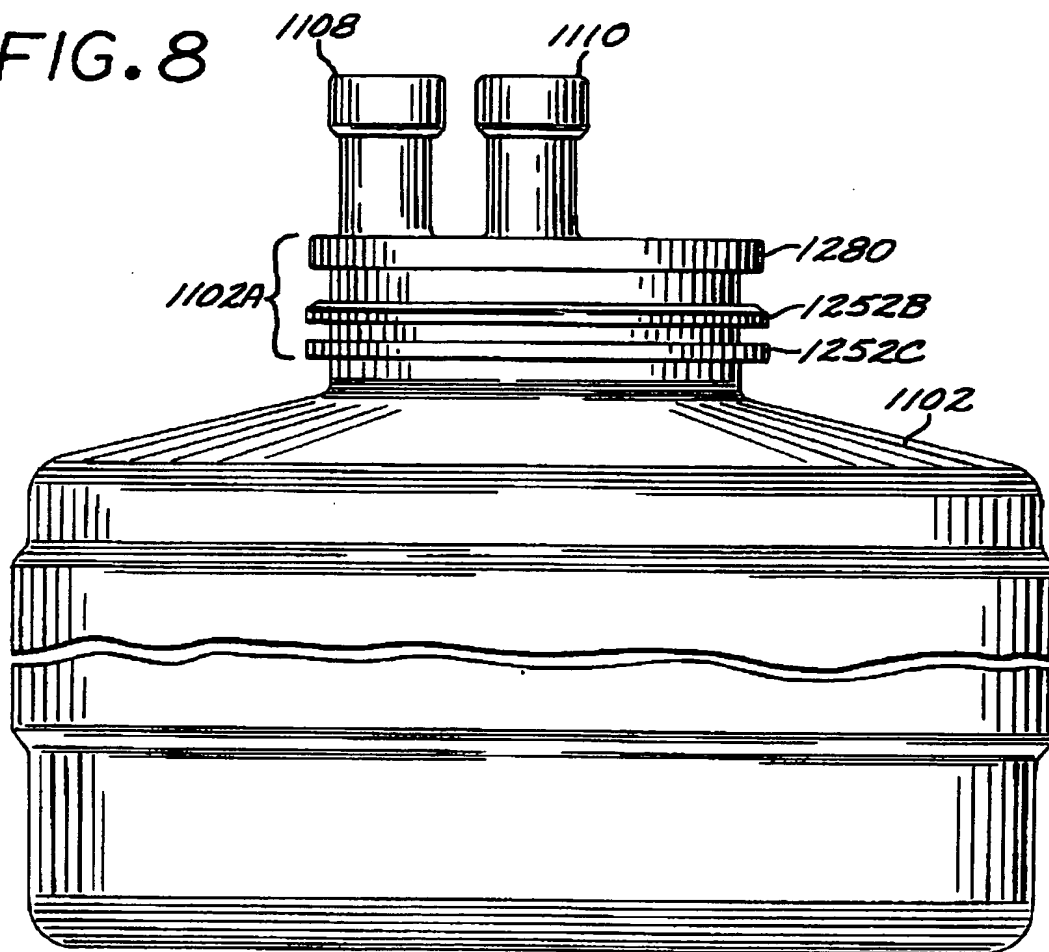
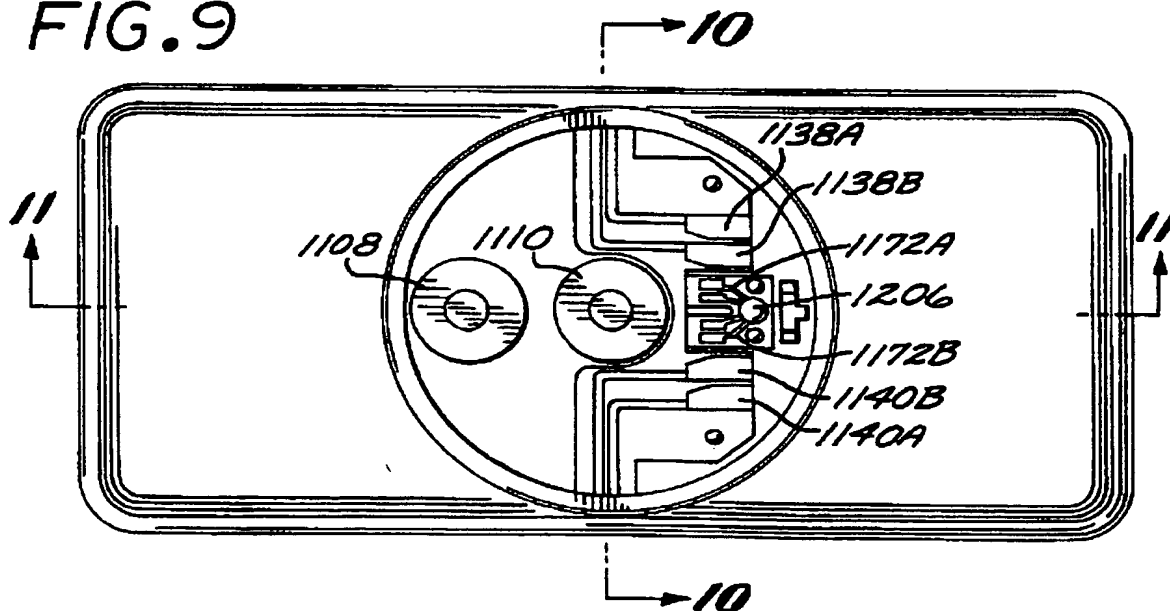
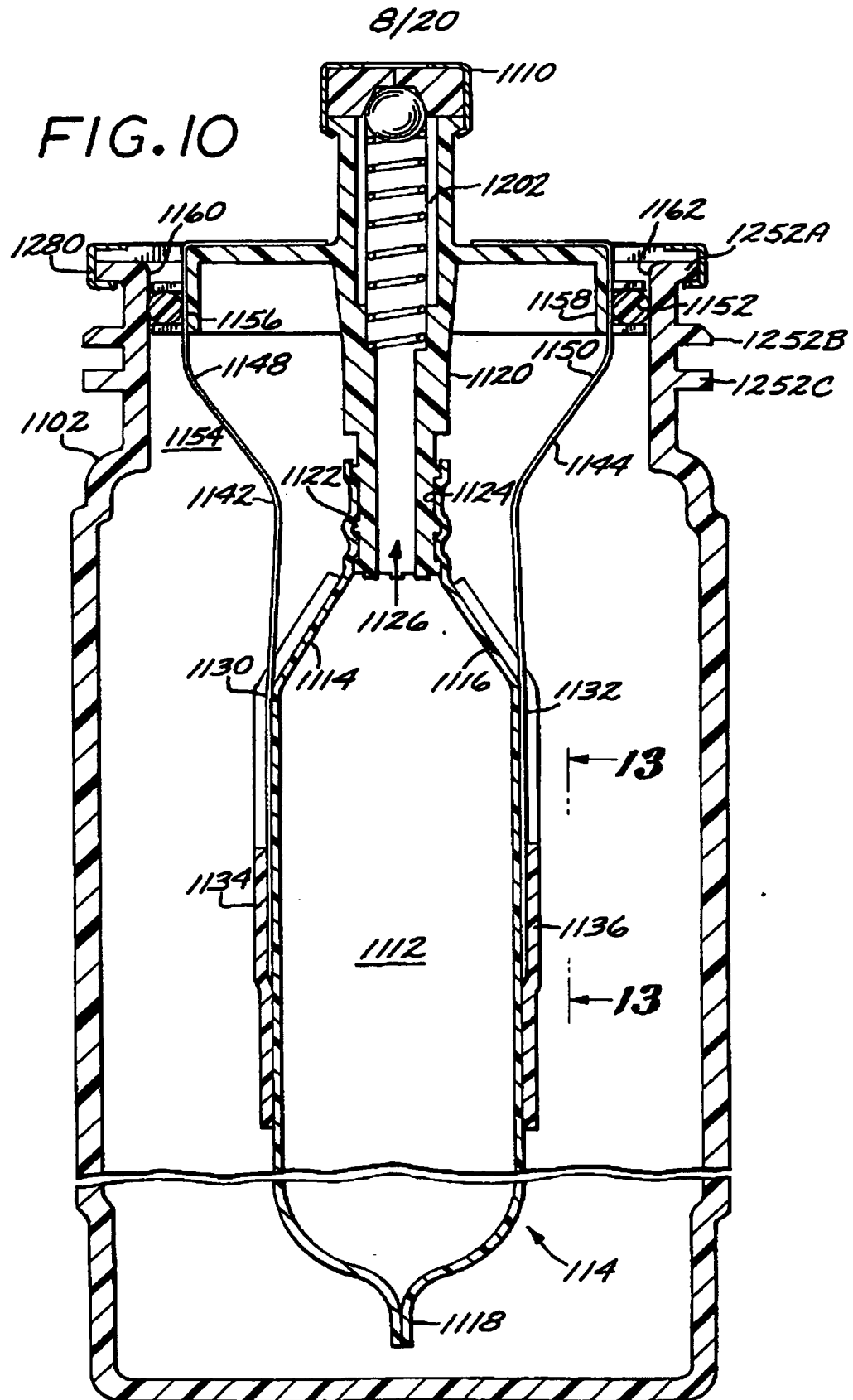


FIG. 9





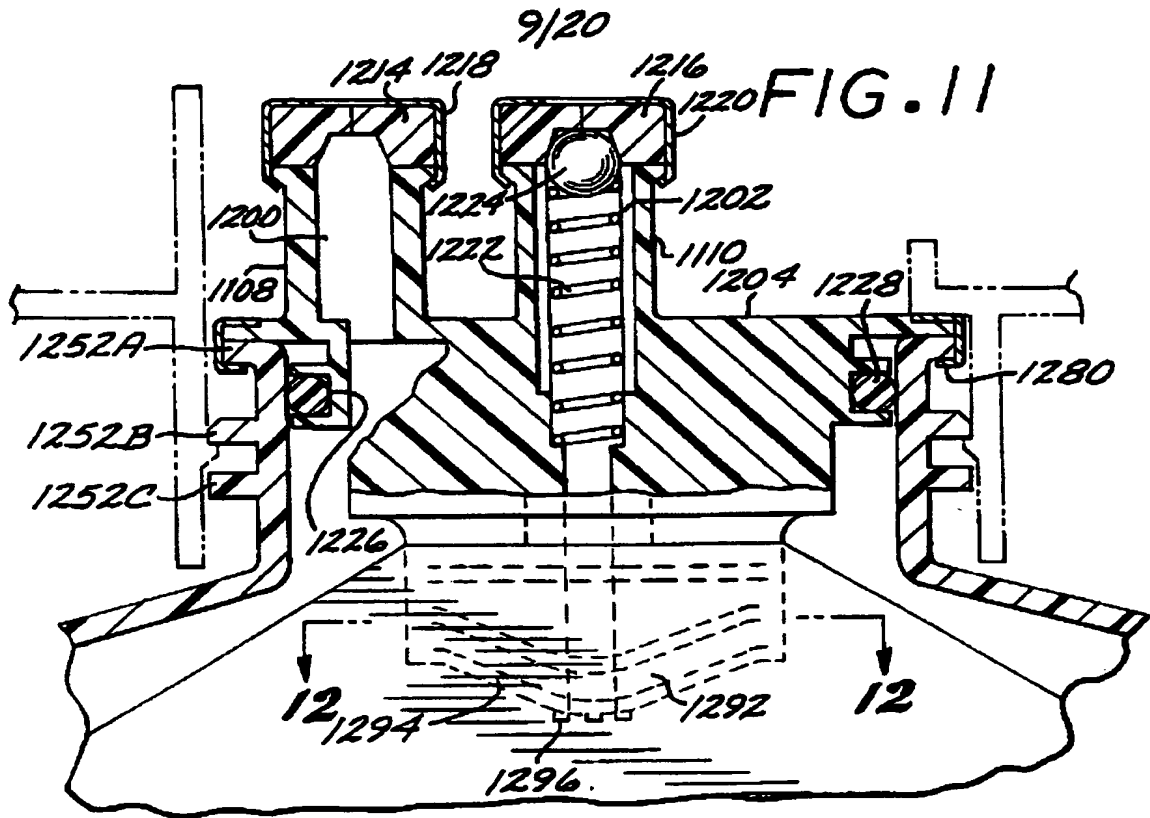


FIG. 12

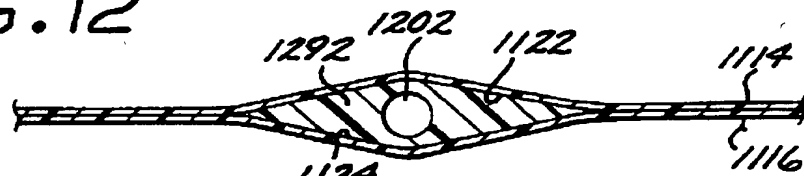
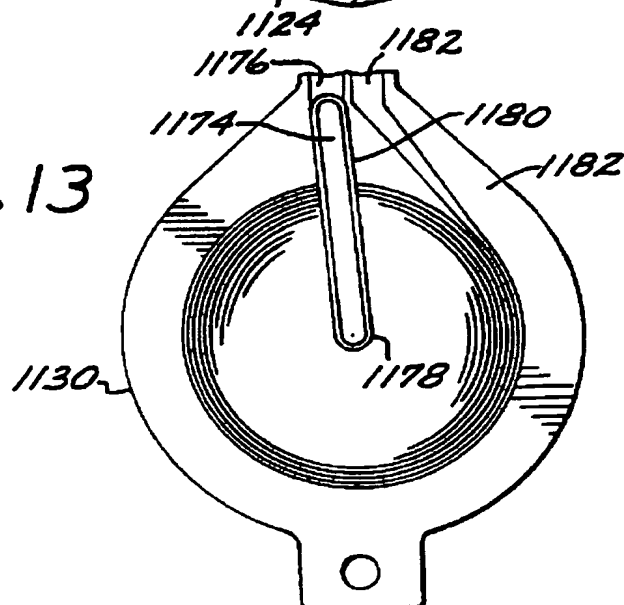


FIG. 13



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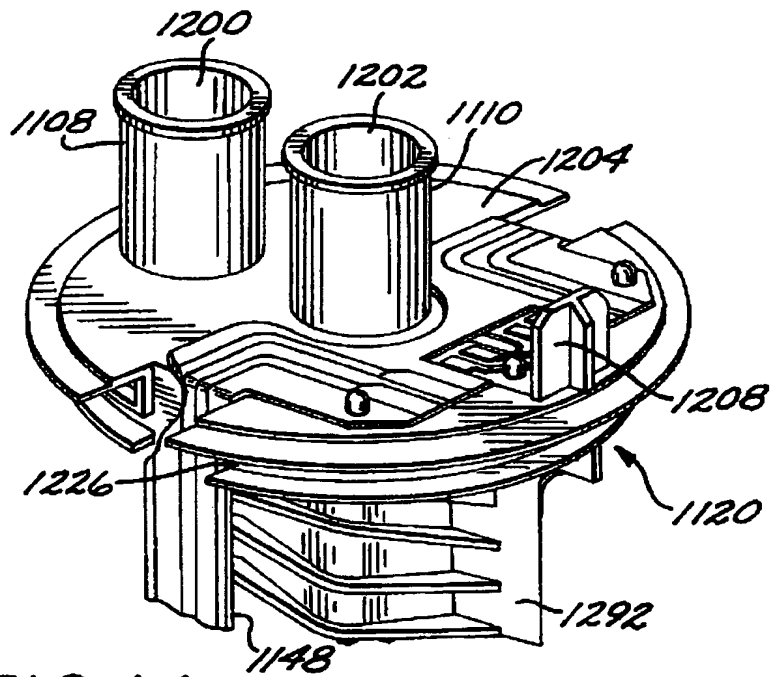


FIG. 14

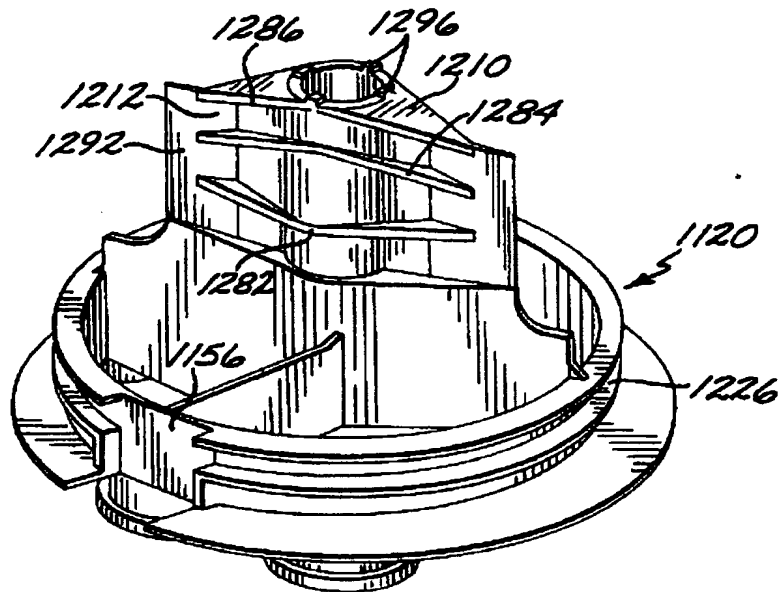


FIG. 15

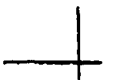
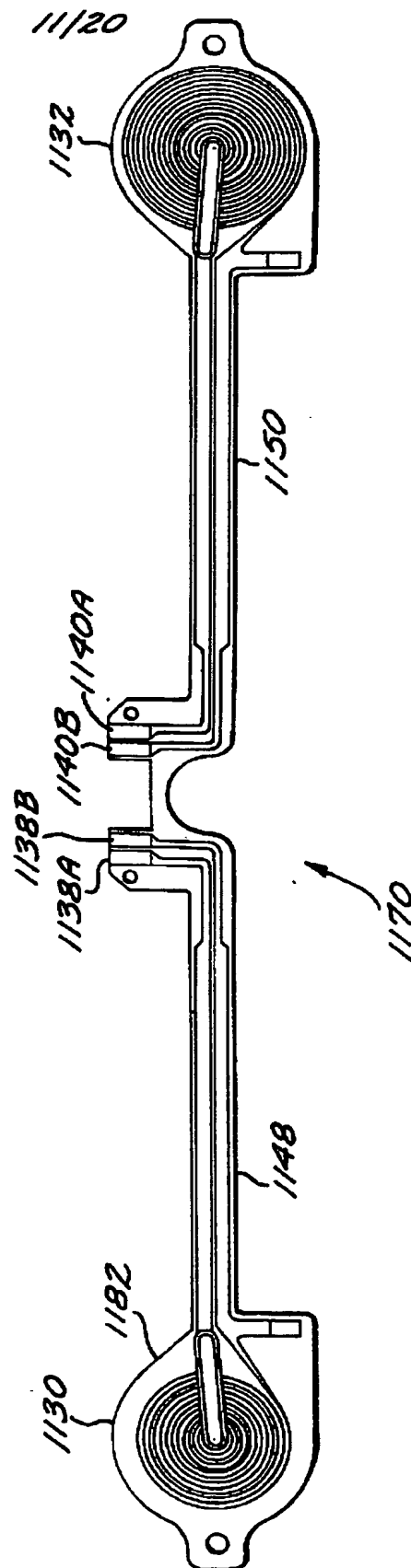


FIG. 16A



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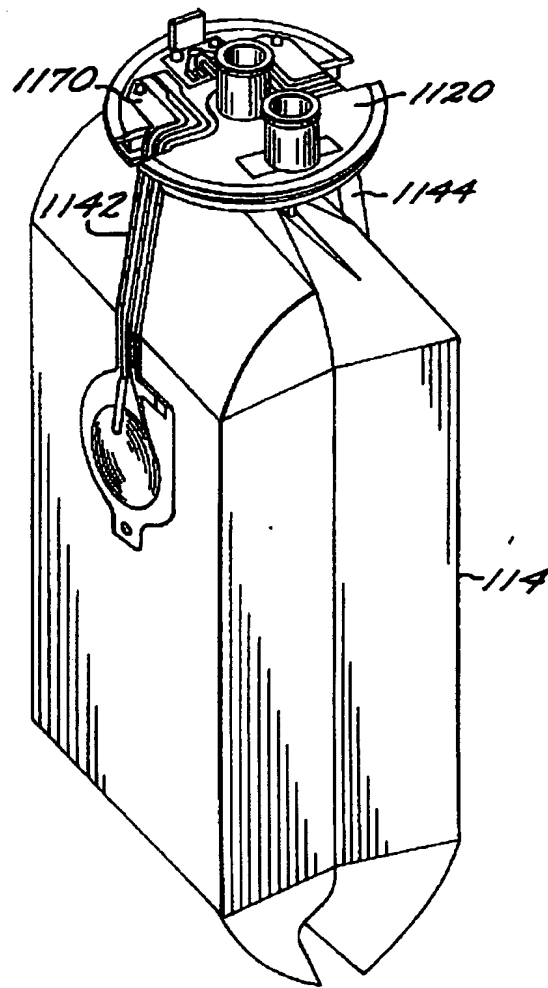


FIG. 16B



FIG. 17

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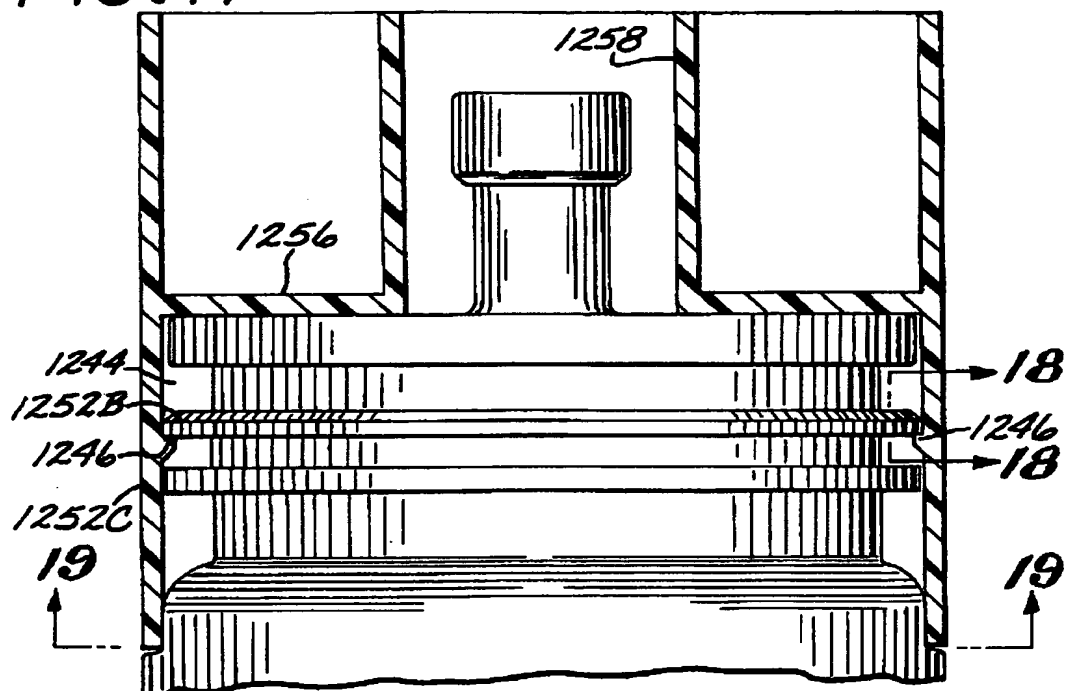


FIG. 18

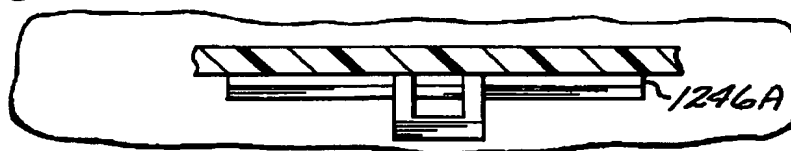
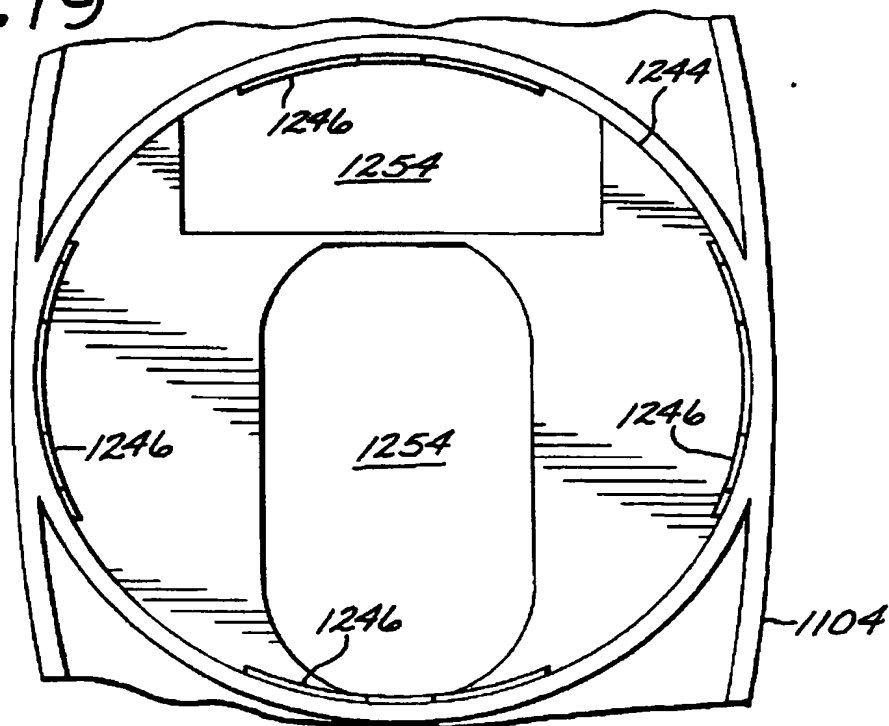


FIG. 19



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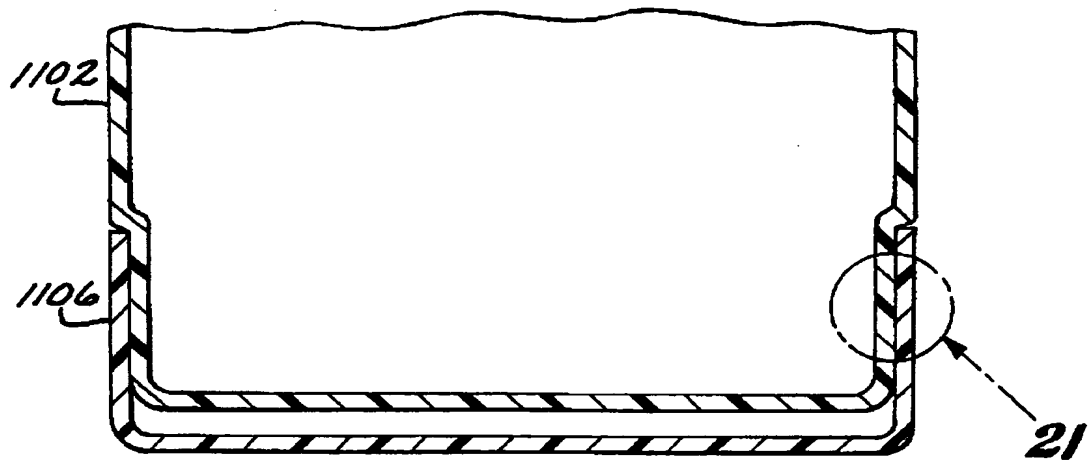


FIG. 20

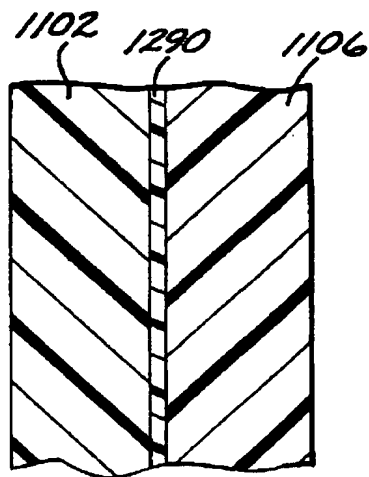


FIG. 21

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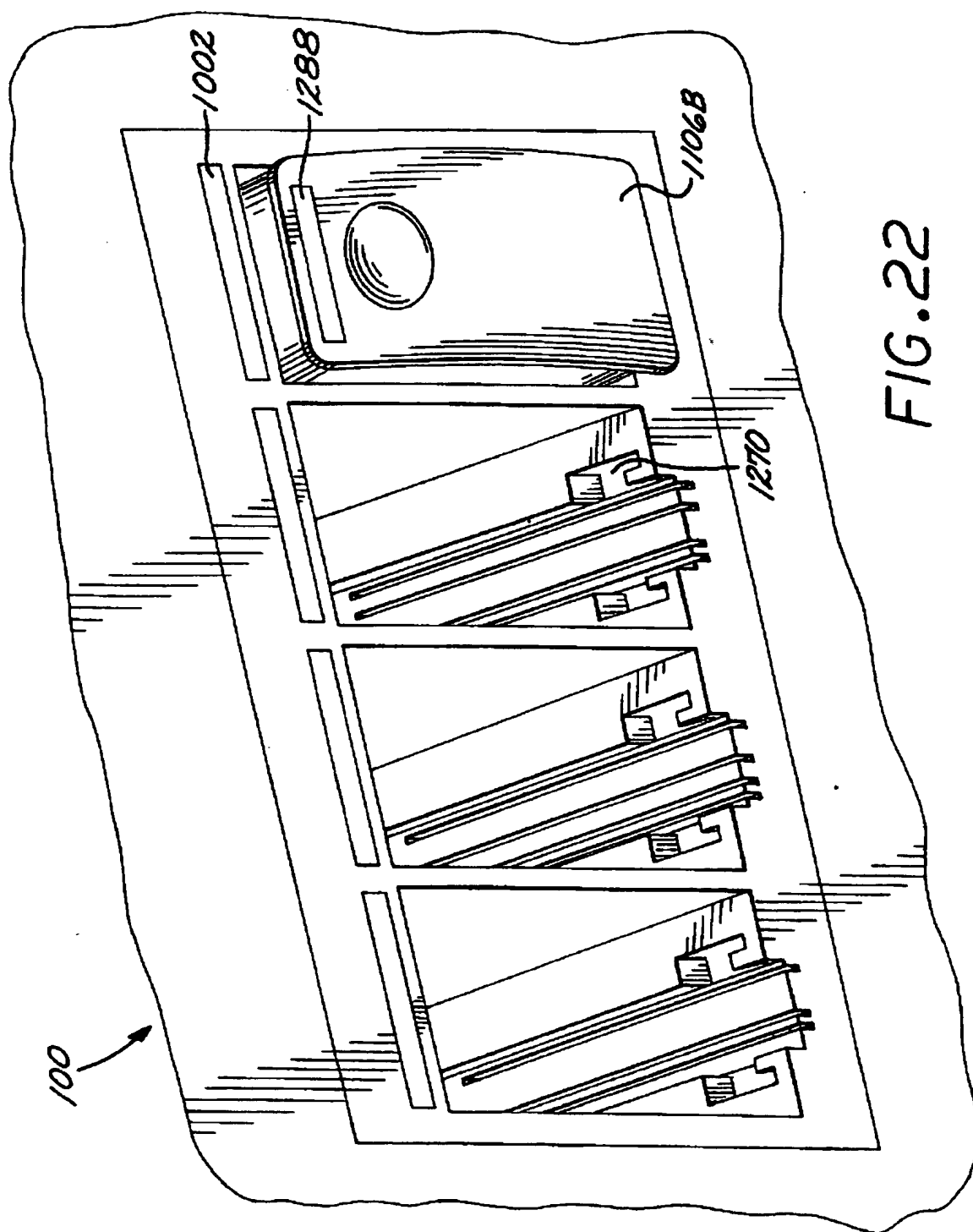
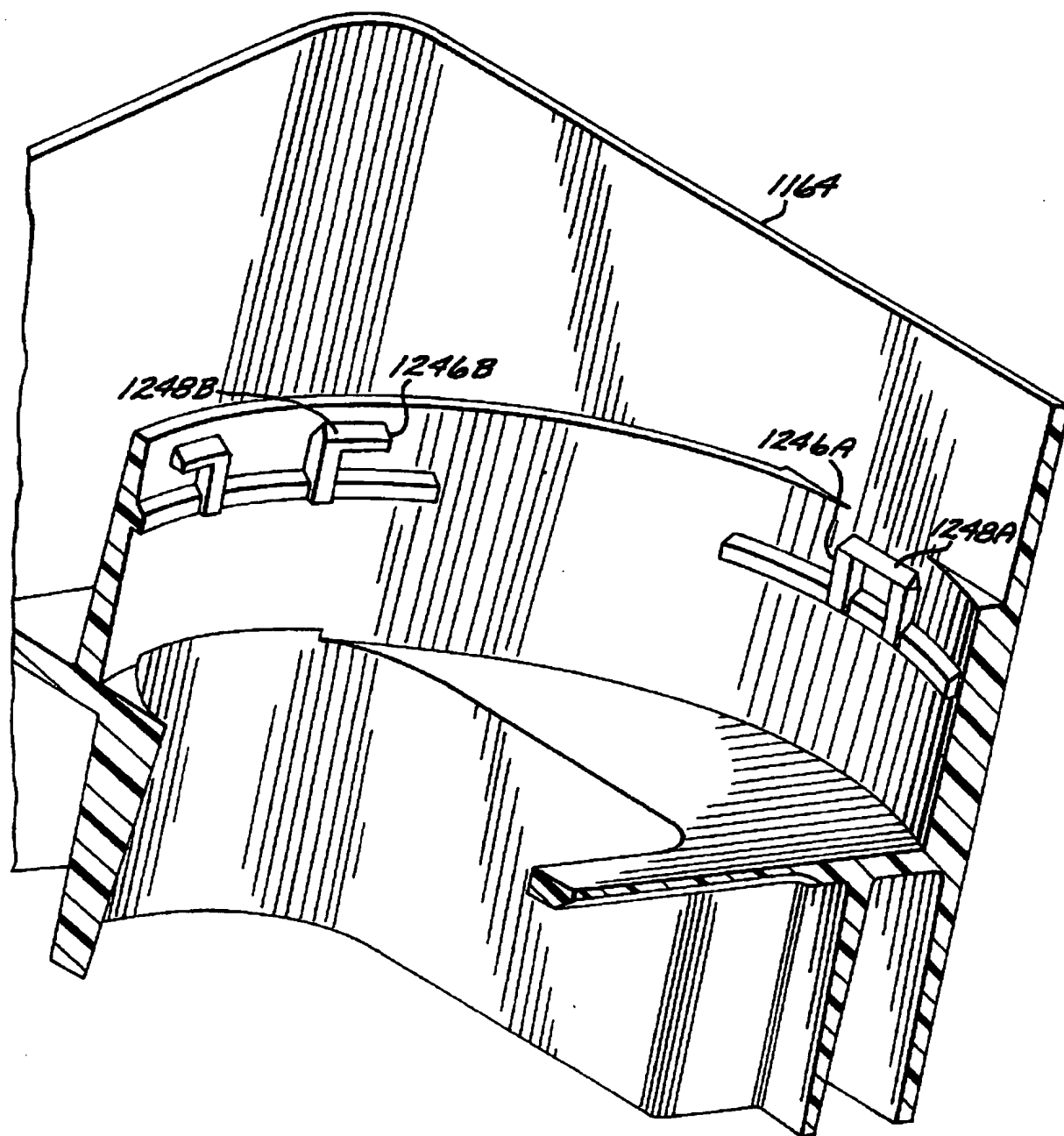


FIG. 22

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FIG. 23



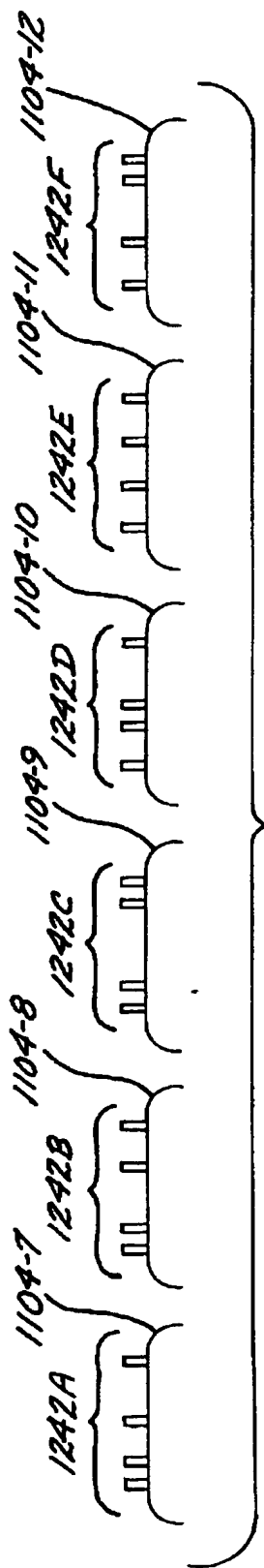
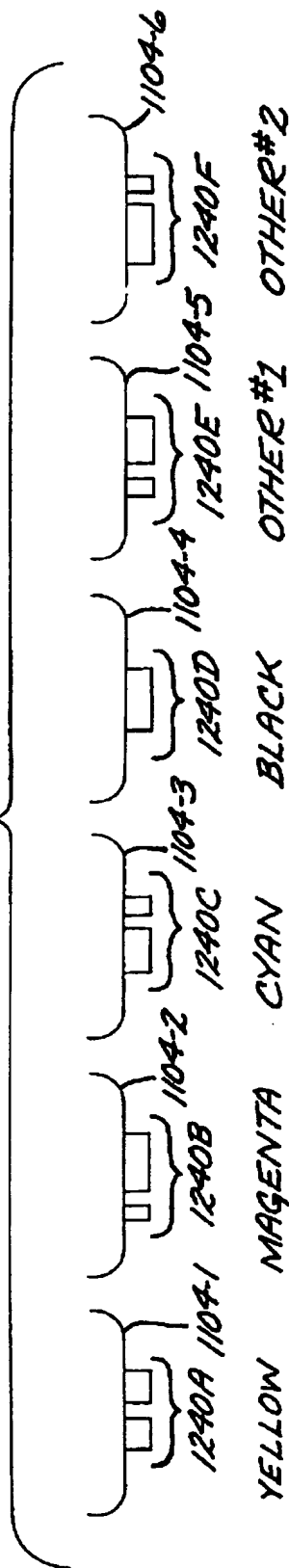


FIG. 24

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FIG. 25



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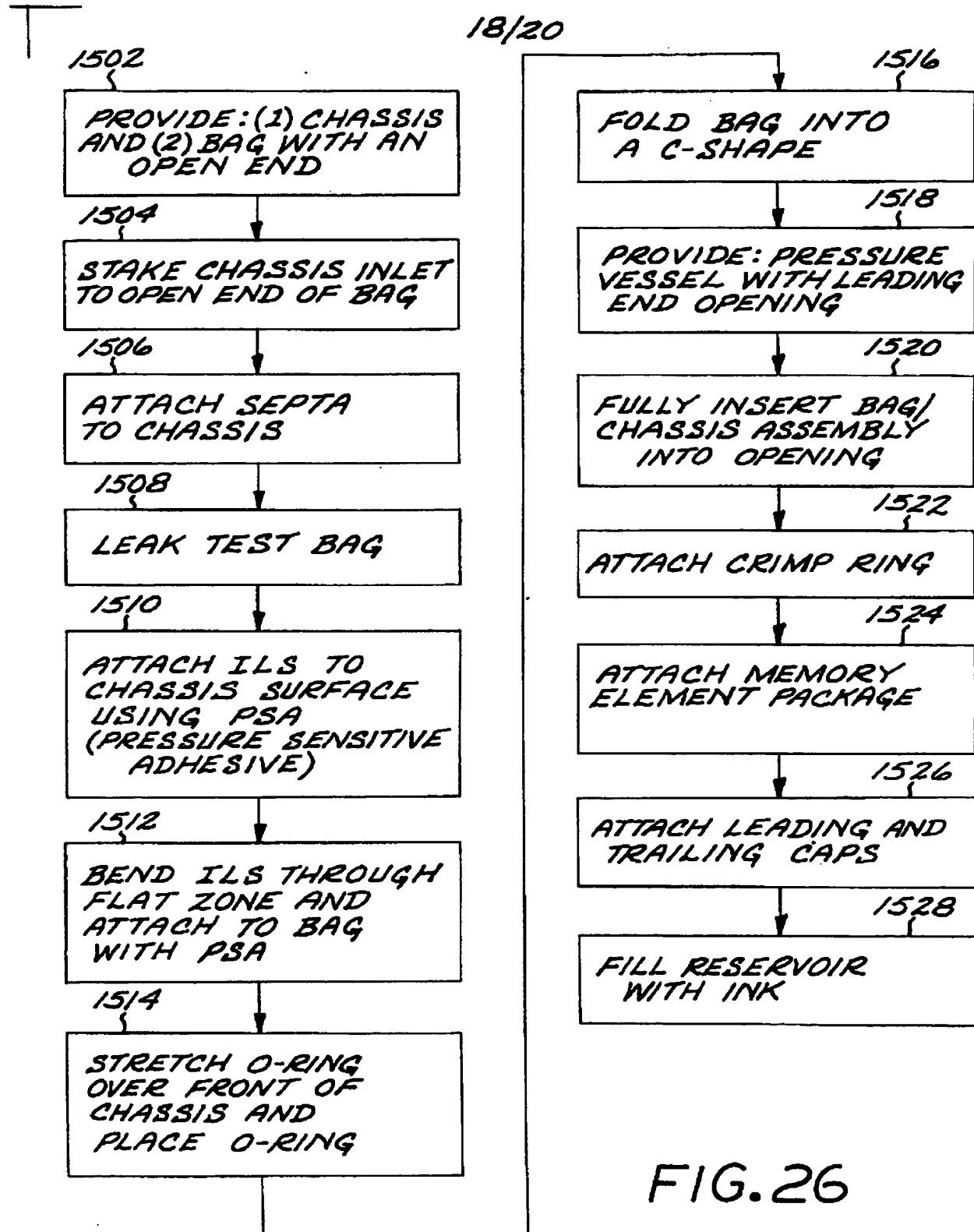


FIG.26

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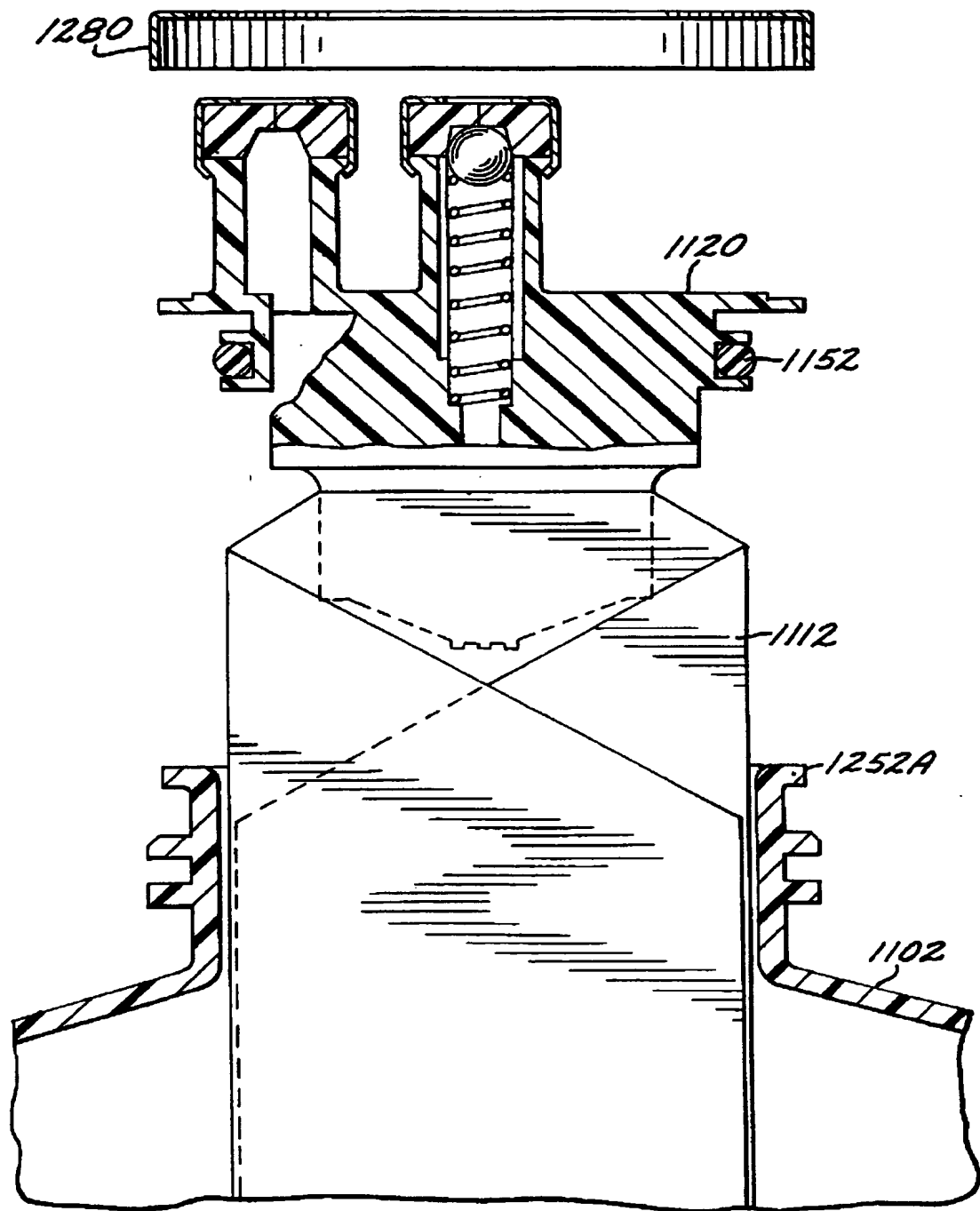
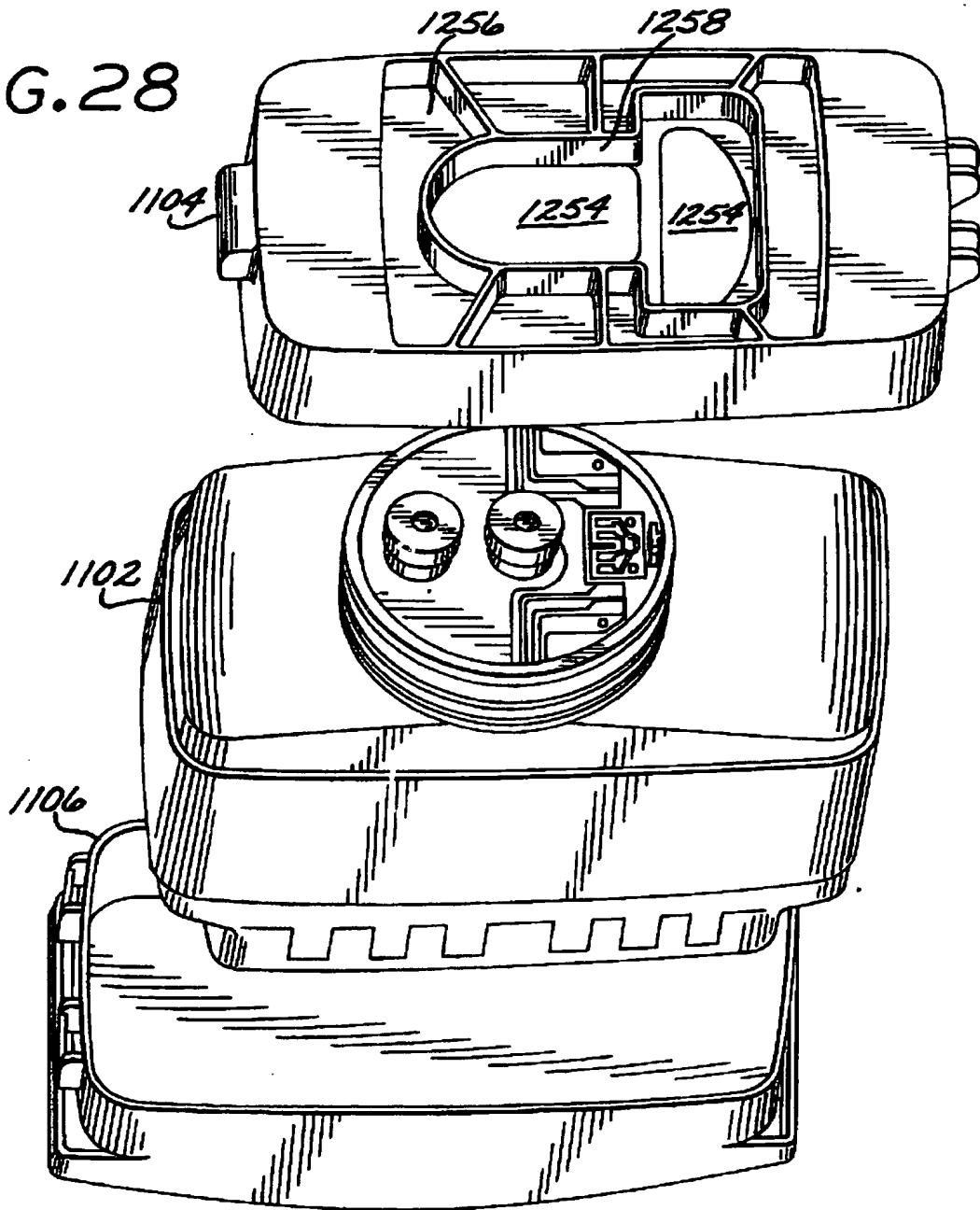


FIG. 27



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FIG. 28



INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 98/11417

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 B41J2/175

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B41J G01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, X	GB 2 312 283 A (HEWLETT PACKARD CO) 22 October 1997 see the whole document ---	1, 17
X	US 4 415 886 A (KYOGOKU HIROSHI ET AL) 15 November 1983 see abstract see column 2, line 44 - column 4, line 13; figures 2-8 ---	1, 17
A	US 4 700 754 A (KRINGE HORST) 20 October 1987 see the whole document --- -/--	1, 17

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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